Section 4 –Methodologies of Fire Engineering

Clause G4.1 Introduction

Fire engineering offers a flexible alternative where compliance with the Deemed-to-Comply provisions in this Code is impractical. It provides an Alternative Solution achieving:

(a) a level of safety that is equivalent to that which would result if fire safety was achieved through full compliance with the Deemed-to-Comply provisions in this Code; or

(b) an acceptable level of safety such that the agreed acceptance criteria and the Performance Requirements are satisfied.

Clause G4.2 Complying with the Performance Requirements

Fire engineering provides a framework to demonstrate that the Performance Requirements are satisfied even though some of the design solutions adopted fall outside the Deemed-to-Comply provisions in this Code where additional fire safety provisions are proposed to compensate for the deviation or shortfall.

If the design being considered is not substantially different from the Deemed-to-Comply provisions or can be readily accommodated by adopting conservative assumptions, it may simply be a case of demonstrating like-for-like substitution or “equivalence” with Deemed-to-Comply provisions and fire safety objectives without having to embark on a full fire safety strategy. However, a practical test is required to demonstrate the equivalence.

Clause G4.3 Assessment Methodologies

There are two types of assessment methods:

(a) Qualitative analysis – use of engineering judgement with documented reasoning and arguments, to compare an Alternative Solution against the Deemed-to-Comply provisions, without calculations.

(b) Quantitative analysis – utilising numerical methods to assess an Alternative Solution, which may involve data and probabilistic methods. There are two means to carry out quantitative analysis, i.e. deterministic and probabilistic.

Deterministic Methods

This method is based on making predictions of the likely outcomes in the event of a fire and selecting appropriate fire safety provisions to achieve the required objectives. Application of this method is typically through showing a level of fire safety equivalent to the Deemed-to-Comply provisions, but it may also take an absolute approach to satisfy the Performance Requirements.

A hazard analysis has to be carried out, followed by an engineering approach based on the accepted fire loads and demonstrating the ability to resist such loads, based on physical relationships derived from scientific theories and empirical results of fire dynamics. The credible fire scenarios, timeline analysis, fire/smoke models and evacuation models have to be established.

Commentary

The approach is often assisted by fire models and computational methods and can offer a more certain indication of achieved safety. Provided the hazards are identified, it is possible to devise strategies for the management or design solutions which will ensure reasonable safety of the occupants, and the protection of essential emergency plant and equipment.

Probabilistic Methods

Risk in the context of fire engineering consists of two components, i.e. the likelihood of occurrence and the consequence. Probabilistic method is essentially an assessment of risk for evaluating the fire safety performance to justify an Alternative Solution. It is based on assigning reliabilities to the performance of various fire safety provisions and assigning frequencies of occurrence of events. The risk of a fire starting and developing with the likely effects of the fire at the worst location and time of ignition should be analysed.

The fire loads, the number and location of occupants and the fire safety provisions should also be assessed to verify whether the acceptance criteria are met. The first two steps are to determine the geometry, construction and Use Classification and to identify the relevant Performance Requirements. The third step is to identify deviations from the Deemed-to-Comply provisions and to propose an Alternative Solution to address the deficiency. The risk levels associated with the proposed fire safety provisions can then be established.

The method is a scenario analysis, considering all possible scenarios. Some parts of the analysis can be quantified with numbers (quantitative analysis), but much of the analysis requires engineering judgement on the development and consequences of a fire and the likely location and movement of people (qualitative analysis).

Commentary

Probabilistic methods require data for events such as fire starts, causes and implications. Due to the lack of such data in Hong Kong, such methods should be used with caution. An absolute risk level evaluation should be carried out only if quality data are available and an acceptable level of risk is clearly defined. Otherwise, a comparative risk evaluation should be carried out to ascertain relative levels of fire safety for the building, where the Deemed-to-Comply provisions are used as a base case.

Probabilistic methods for assessment can only be of limited use due to the lack of internationally recognised and mature assessment methods. At present, there are no tools available for calculating risk in absolute terms, which have been successfully validated and are reliable in their operation.

Evaluation Acceptance - Equivalence or Absolute

One of the most accepted approaches of demonstrating that an Alternative Solution complies with the Performance Requirements is a process of demonstrating “equivalence” (or carrying out a comparative assessment). The term “equivalent” is used to show an Alternative Solution adopted achieving a level of fire safety comparable with the level of safety achieved by the Deemed-to-Comply provisions.

Demonstrating equivalence to the Deemed-to-Comply provisions is where equal performance between the designed system and what is expected under full compliance with the Deemed-to-Comply provisions is achieved i.e. the outcome under a given fire scenario should be similar for either the complying system or the proposed Alternative Solution.

The fire safety performance of an element or fire safety sub-system should be compared to the level of fire safety that would be achieved in an identical building in which that element, or fire safety sub-system is designed in compliance with the Deemed-to-Comply provisions.

There are two evaluation methods to establish the level of fire safety for a particular Alternative Solution.

The use of “equivalent level of fire safety” is one evaluation method for assessing the fire safety level achieved by an Alternative Solution. It is often the base-line performance for fire engineering.

The other method is an absolute evaluation. An absolute evaluation is carried out where the results of the analysis are matched against the Performance Requirements without comparison to the Deemed-to-Comply provisions, hence requiring agreed acceptance criteria. This requires more substantiation through calculations and also requires prior agreement of the analysis inputs and acceptance criteria by the Building Authority.

Clause G4.4 References

The following are useful references:

- *International Fire Engineering Guidelines*, Australian Building Codes Board, Canberra, Australia, Edition 2005, 2005.
- Drysdale, D., *An Introduction to Fire Dynamics*, 3rd Edition, John Wiley and Sons, Chichester, UK, 2011.
- Society of Fire Protection Engineers, *SFPE Handbook of Fire Protection Engineering*, National Fire Protection Association, Quincy, MA, 4th Edition, 2008.
- Klote, J.H., and Milke, J.A., *Design of Smoke Management Systems*, American Society of Heating and Air-Conditioning Engineers, Inc., Atlanta, GA, 1992.
- NFPA 92B, *Guide for Smoke Management Systems in Malls, Atria, and Large Areas*, National Fire Protection Association, Quincy, MA, 2009.
- *CIBSE Guide E Fire Safety Engineering*, The Chartered Institution of Building Services Engineers, London, 3rd Edition, 2010.
- Karlsson, B., and Quintiere, J. G., *Enclosure Fire Dynamics*, CRC Press, Boca Raton, FL, 2000.
- Pauls, J.L., and Jones, B.K., “Building Evacuation: Research Methods and Cases Studies”, *Fires and Human Behavior*, John Wiley and Sons, New York, 1980.
- BS 7974, *The Application of Fire Safety Engineering Principles to the Design of Buildings*, British Standards Institute, London, 2001.