

FUTURE OF FIRE SAFETY FOR MALAYSIAN HOUSING

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ABSTRACT

Fire is very dangerous and life threatening. Although not all fire resulting in death but the number of death during a fire are rather alarming. It is further worsen if the fire occurred during nighttime, in highly populated resident area such as multi-storey flats and squatters area. Although not all fire resulted in death, fire in buildings will cause the loss of properties and in extreme cases can lead to progressive collapse.

Therefore fire safety has always been an essential requirement for buildings. Fire safety has commenced from prescriptive based and then improve to performance based. Nowadays, as more studies and research had been done in perfecting and evaluating performance based, a rational approach towards fire safety had been developed.

As the modern architecture and engineering continues to evolve in practicability, rational approach in fire engineering had to be adopted. A rational engineering approach in fire safety engineering mainly by integrating prescriptive based and performance based for overall life safety. It will be based on principles of reasons, common sense, science, engineering and practicability. A new way looking into fire safety engineering will make fire safety building codes more reliable, realistic and cost effective.

1. INTRODUCTION

Despite the high number of fatalities, the collapse of World Trade Centre in New York is an invaluable lesson to structural engineers. The catastrophic incident on the 11th of September 2001 was the result of high temperature hydrocarbon fuel feed fire on thermal insulated steel. Eventhough the likelihood of such carnage in building is not an everyday event but to certain extend it has evoked the fire safety engineering and policies on tall building. However the incident of 11th September it's not seen to affect fire safety of low-rise buildings.

According to Jabatan Bomba dan Penyelamat Malaysia statistical report for the year 2001, 62 deaths were reported due to incidents of fire. Incidents of fire reported were in housing, industrial, garages, offices and shops. No information was available on the number of death due to fire in housing. It was also reported that fire causes damage and lost in assets worth more than RM 500 millions for the year 2001 in Malaysia.

The primary goal of fire safety is preserving life; life safety with no permanent damage to health. Thus, buildings must be designed so that in the event of fire, the occupants can either remain in place safely, evacuate to another part of the building where it is relatively safe or totally evacuate the building without exposed to unhealthy, hazardous or untenable conditions.

The life safety also concern with the life of fire fighter. Fire fighter is expected to assist in evacuation, rescue and prevent extensive uncontrolled spread of fire. Therefore appropriate fire resistance levels are needed to facilitate safe fire fighting for the purpose of controlling the fire and evacuation. The building

must be able to resist progressive collapse both inside and outside the building during the time required for fighting the fire.

Properties although not as important as lives, take an essential part of the well being of society. Property protections to a building include protection of the structure and the fabrics of the building and protection of the contents of the building. However properties protection will take social aspect such as protection from fire to adjacent buildings, interruption in business activity and public image.

Extensive research on Cost of Fire Regulation Non Compliance¹, Reducing Fire Hazard For Low Cost Housing in Labuan², Fire Safety Assessment³ and Structural Fire Engineering Investigation⁴ had been conducted locally. The trend on fire safety in buildings has move towards performance based rather than prescriptive based. In prescriptive based buildings are protected against fire through passive and active fire protection such as cementitious spray and sprinklers respectively. In performance based fire engineering, buildings are designed to incorporate fire resistance of the building. However, a more realistic approach that include prescriptive and performance based will result in reduction in lost of life, property damage and cost-effective building constructions.

2. PRESCRIPTIVE BASED

Currently in Malaysia, fire-resistance design philosophy is based on a prescriptive approach. The behaviour of structures is evaluated based on the critical members subject to a standard ISO 834 fire where it is normally expressed in units of time. The required time for fire resistance is usually expressed in terms of multiples of 30 minutes: for example 30, 60, 90 minutes, related to ISO Standard fire. Uniform Building by-Laws Malaysia⁵ adopted these standards and prescribes fire resistance time where members are not allowed to exceed their failure criteria.

Regulation^{5,6} required certain elements of structure to have fire resistance depends upon such things as size, use of building and function of the element. When exposed to fire, all commonly used structural materials lose some of their strength, for example, concrete can spall exposing reinforcement, timber sections deplete by charring and steel members eventually lose strength⁷. Therefore, according to prescriptive based structural materials has to be protected against fire for required time of fire resistance as shown in example in Figure 2.1. Generally, prescriptive approaches are the results of regulation, insurance requirements, industry practice or company procedures.

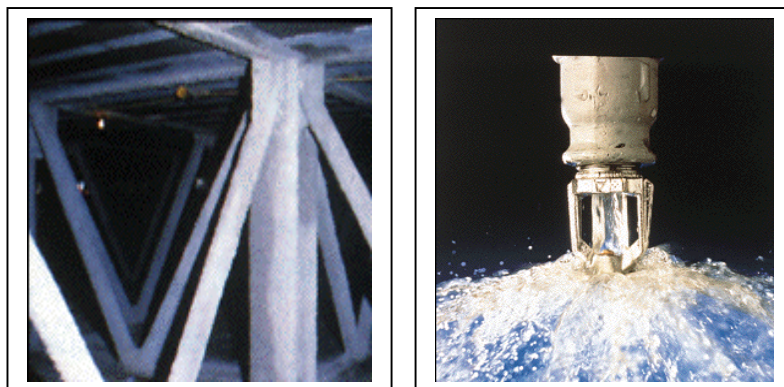


Figure 2.1 Spray Protection System and Sprinkle

The fire resistant based on prescriptive method is not realistic due to the followings reasons⁸.

1. It is unrealistic to carry out fire tests for all combination of steel section sizes and shapes, load levels and different structural configuration
2. The time-temperature relationships in the ISO fire does not represent real fires

3. Fires normally occur in small compartments and a large part of the structure remains cool. The cooler part can support and divert load paths from weakened members and this exercise will lower the temperature on the heated part.

3. PERFORMANCE BASED

Performance based fire safety are based on evaluating analyzing and the development of the most appropriate method to protect against this hazard. The performance-based fire safety design process will be achieved as shown in Figure 3.1.

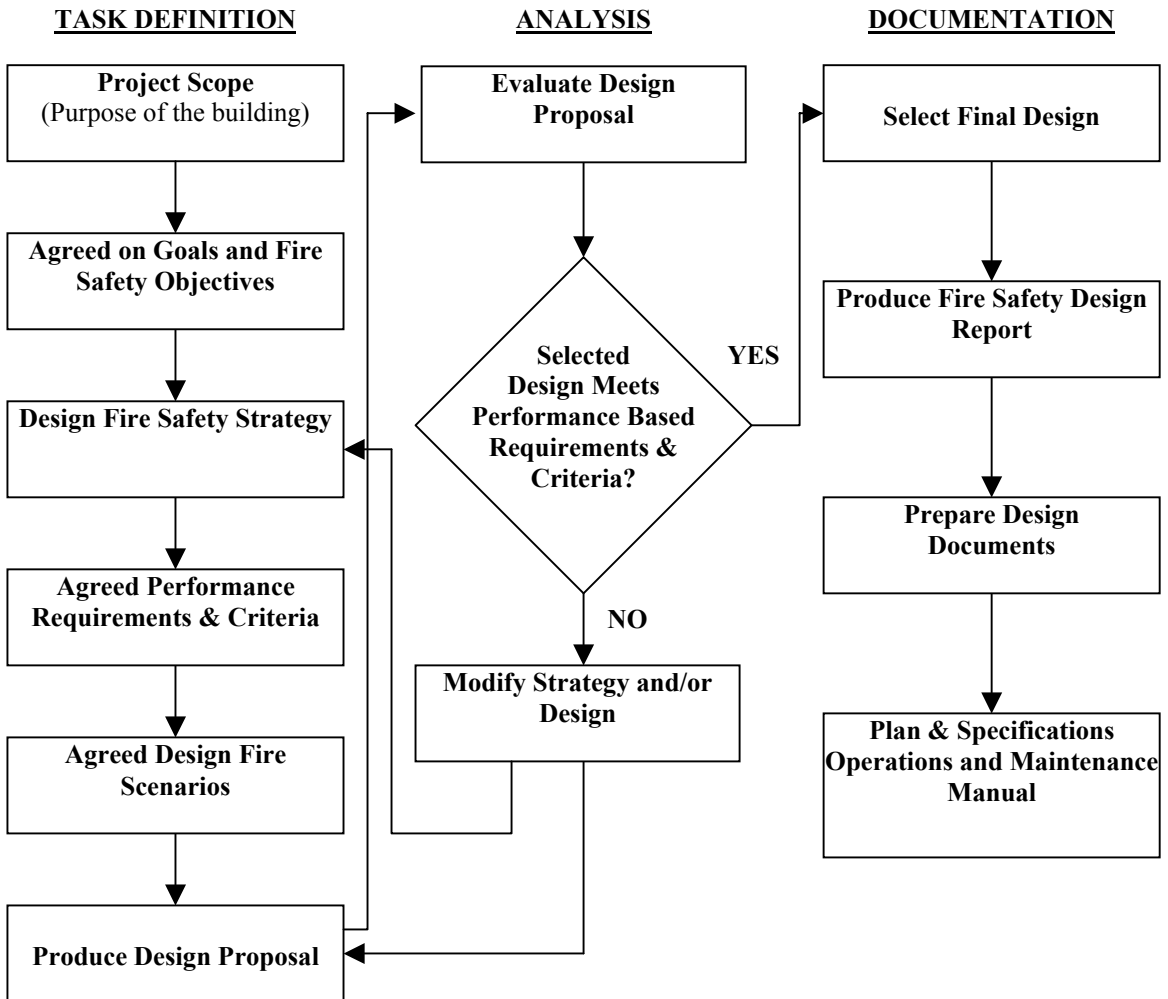


Figure 3.1 Overview of the Performance-Based Fire Safety Design Process⁹

Fire safety strategies are to avoid propagation of smoke and toxic gases within and outside the building, propagation of fire in terms of heat transfer within the building and failure of buildings elements, particularly if this leads to progressive collapse.

When establishing performance criteria for fire resistance of building elements, it is necessary to consider all possible failures modes to achieve safety margins of the design. Below are the failure mode (limit state) and the relevant failure modes. (Table 3.1)

Limit state conditions

1. **Smoke leakage** - propagation of smoke and toxic gases, within building or into the open, will occur if a significant quantity of combustion is able to pass through separating elements
2. **Thermal insulation** - fire spread through a barrier by thermal propagation either by convection, radiation or conduction.
3. **Integrity** - a condition where combustible gases passes through the barrier after the formation of cracks or gaps.
4. **Load bearing capacity** – structural failure of a building elements occurs if the load bearing capacity becomes less than the actual loading, as a result of a reduction in the mechanical strength of the building at elevated temperatures and the redistribution of the mechanical loadings.

Table 3.1 Relevant Failure Modes

Purpose of construction elements	Failure modes
Resistance of spread of hot gases for evacuation and limitation of damage to the building contents	Smoke leakage and integrity
Resistance to spread localised or fully developed fire for evacuation or to prevent damage to the building fabric	Smoke leakage, integrity and thermal insulation.
Resistance to spread localised or fully developed fire for evacuation and fire fighting access	Smoke leakage, integrity, thermal insulation and load bearing capacity
Containment of fully develop fire for the purpose of loss reduction, with the assistant of fire fighters	Integrity, thermal insulation and load bearing capacity
Containment of fully develop fire for complete burnout for the purpose of loss reduction, with the assistant of fire fighters	Integrity, thermal insulation and load bearing capacity related to deformation limit state
Containment of fully develop fire for complete burnout for the purpose of loss reduction, without the assistant of fire fighters	Integrity, thermal insulation and load bearing capacity related to deformation limit state

4. RATIONAL APPROACH TO FIRE SAFETY IN BUILDINGS

Increased understanding of fire and the development of fire safety engineering have opened up possibilities for a more flexible approach to fire resistance. Thus, the combination between performance based and prescriptive based will further enhance the reliability of Fire Safety Engineering.

In practice, various safety factors were implemented in design of a building. Rationally, the probability of the building to face natural disaster such as fire and earthquake are unlikely to happen everyday. In reality there are buildings that are not exposed to any disaster throughout its entire life. Furthermore, protection based on standards rather than actual hazard is costly. Therefore, in rational approach to fire safety in building, all factors including the location, the used, available resources and the probability of disaster of the building had to be considered.

According to CIB W014 Fire Group, a rational system for fire safety of a building requires the safety objectives to be identified explicitly. Fire safety objectives identified for a specific project must also be the basis for the specification of the fire resistance property. Modern fire safety design of buildings takes into account both the buildings (materials, layout) and the occupants therein. A critical step in the design is to develop characteristic data for the design for example, what and who will be in the building when fire begins.

Fire Safety Engineering had to be applied in design stage, occupancy stage and during fire stage, where all fire safety objectives and possibilities were considered. Fire resistant performance aspects can be divided into Fire Detection, Smoke Separation, Fire Separation and Structural Reliability.

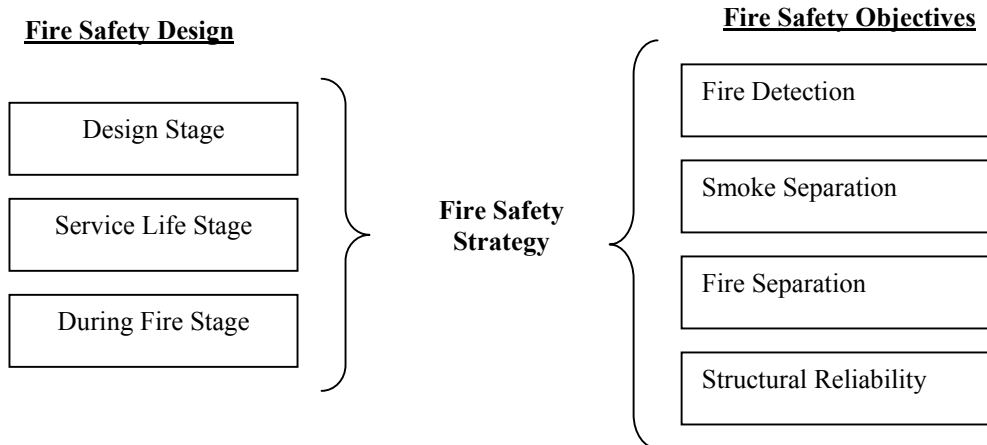


Figure 4.1 Elements of Fire Safety Strategy

In Figure 4.1, fire detection is one of prescriptive based function that can be integrated in the fire safety engineering. Fire detection using smoke or heat detector will give an early warning to occupants and this will ensure speedy egress out of the harm. Fire detected in early stages is very important because it will ensure the prevention of fire. This can further explain in Figure 4.2, where when the stage of fire is past the point of flashover, prevention as a prescriptive based will change to fire safety measures by combination performance and prescriptive based.

Smoke separation will ensure that the spread of smoke is prevented or restricted because smoke can move very quickly over large distanced in a building and fire separation will ensure that the fire including the smoke and heat cannot move or spread from Point A to Point B within specified time period. The prevention can be achieved in implemented the compartmentation in buildings by using fire resistance doors and walls. Structural reliability will ensure that the structural system of a building continues to operate effectively for the full duration of a fire or other actual environmental conditions encountered in the building.

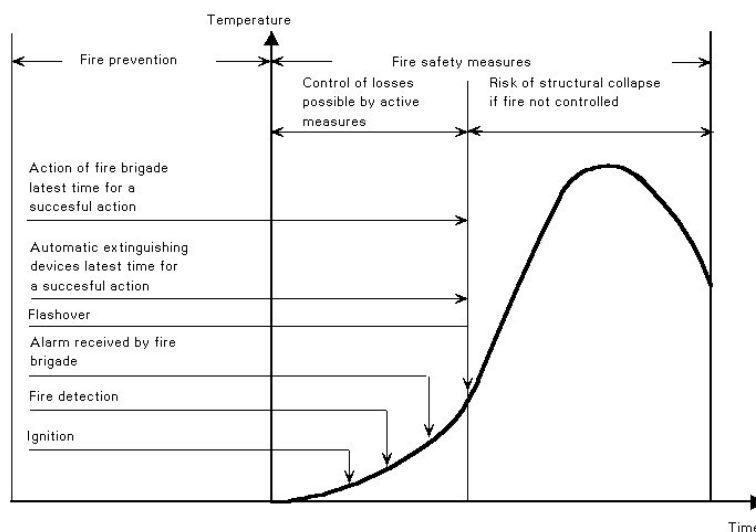


Figure 4.2 Fire Precaution Measures and Condition For Effect

The rational approach will ensure all the fire safety engineering objectives listed below accomplished:

- Building compartmentation and fire ratings for fire and smoke containment
- Probability analysis and risk assessments
- Occupant behaviour in fire situations
- Fire detection and alarm systems for early detection of smoke and activation of alarms.
- Assessment of anticipated fire loads
- Smoke hazard management systems for control of smoke within the building
- Emergency warning systems for early warning to building occupants
- Active fire protection systems such as fire sprinklers for control of fire spread and products of combustion.
- Egress provisions, egress times and travel distances
- Fire Brigade access and fire fighting provisions.

5. CONCLUSION

By adopting a fire engineered approach with the prescriptive requirements of the Building Codes, all fire protection provisions are considered in a totally integrated manner resulting in more cost effective design solutions for the equivalent level of life and property protection. Performance and prescriptive based combined will complement each other. Combining the prescriptive and performance based as a rational approach in fire safety engineering will ensure unnecessary redundancy in the fire safety measures, therefore be avoided, and often considerable cost reductions can be achieved.

The approach in determining the appropriate fire protection systems in building also can be based on the use of the building, the probabilistic of hazard occurring to the building and engineering judgment. To achieve it, the validated sets of data, researches and knowledge on fire safety engineering are essential which require understanding of building design process, fire scenarios, interaction and behaviour of building in fire and service required to maintained the building fire safety. Thus, the transition from the method used today to rational approach in fire safety will be quite a challenge in Malaysia

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