Fire Safety in Buildings -An Engineering Approach

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ABSTRACT

In most countries fire safety in building design is achieved by strict compliance with a set of very well defined regulations. In general these have grown up in response to major fire incidents which may go back many centuries and which may be entirely inappropriate for modern buildings. The general goal of fire safety regulations is to provide life safety and sufficient protection to property in case of fire. To achieve this goal, requirements for structures, building materials, evacuation arrangements, and relative locations of buildings act to define how buildings should be designed and constructed for their respective use. The requirements are related to prevention of ignition and fire spread, limitation of fire growth, evacuation provision, load-bearing capacity of structures and prevention of spread of fire between buildings. This paper illustrates the use of fire engineering in building design and explains what we mean by fire safety engineering and how it has to be used in practice.

1. INTRODUCTION

Fire safety regulations can be divided into prescriptive and performance based codes. There is a worldwide move to performance based codes rather than prescriptive codes. The new performance based codes facilitate the use of fire safety engineering design. Whilst the move to performance based fire safety regulations provides greater opportunities for the use of fire safety engineering design of buildings, it is only in exceptional cases that the opportunity is exploited at the global level i.e. that the overall fire safety objective is realized using an engineering approach to the problem. The use of the available science is confined to resolving problen associated with discrete parts of the fire safety desig especially where the regulations or the technical suppo documents to the regulations are unable to accommodate design feature or where a particular approach is deemed to l unacceptable according to prescriptive supportir document.

2. PRESCRIPTIVE CODES

In general, most codes in all countries continue to l prescriptive documents. These have grown up as a result of disasters, which have highlighted weaknesses existingdesigns. Prescriptive (specification types) cod often specify their requirements with no statement objectives, little or no opportunity to consider alternati strategies, no place for engineering calculations, and flexibility to adapt to unusual situations. They specifi requirements for fire resisting construction and means escape, but it had no stated objectives and was very difficu to adapt to unusual situations. As long as buildings contin to be constructed in a conventional way, these rules ar standards, which are in general quite pragmatic, will ser the design community well. However, as soon as desig tend to depart from the norm, difficulties arise. Not only ma existing approaches frustrate new designs, but also t imposition of outdated rules on new buildings may give illusion of safety, which is not achieved in practice. Th there is a need for performance based codes.

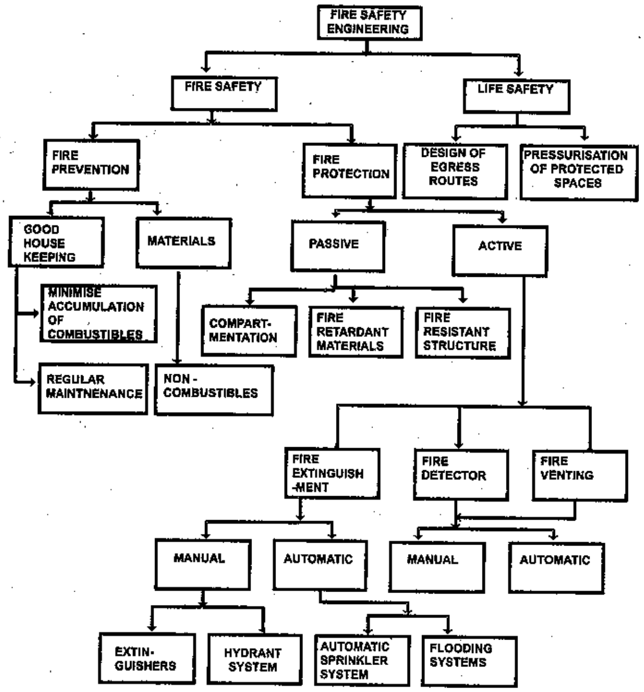

Fig. 1 : Fire safety engineering network

Active fire protection is provided by applying fire extinguishing agents to the burning materials through extinguishers/hydrants/sprinklers or by introducing theminto the fire environment through flooding systems. The application of extinguishing agents could be manual or automatic. The most widely used extinguishants are water, carbon dioxide, foam compounds and dry chemical powders. The provision of safe means of escape helps to maximize the safety to the life of the occupants. Although both aspects are complimentary to each other, certain minimum number of additional measures are required to achieve satisfactory level of safety. For example, it is possible to reduce the level of risk to the occupants of a building by providing enough number of large width escape routes and means to pressurize them with fully protected spaces within the building to allow unescaped occupants to congregate till the fire is extinguished.

In an another example, where two fire safety de strategies have been proposed. Only passive fire protec systems are considered in the first strategy and in the sec one both passive and active systems have been conside Clearly, in the second strategy the level of passive protection may be less than the level pertains to first strat to maintain the same level of fire safety. It is, theref essential for a fire protection engineer to have tools to pre the behaviour of individual components of fire safety in c of a fire. The development of the capability to predict level of fire and life safety requires a set of models to quan the performance of building fire safety system. While m progress has been achieved to develop mathematical mo to predict the growth and spread of fire, the response building components, and fire safety measures to fire, eff are needed to have a comprehensive model which can be u in totality to achieve the satisfactory level of safety.

The key to improved design is defined goals. If regulations state that the risk to people of death or injury to fire should be no more than a particular level, then i open to designers to show how this could be achieved i number of ways. The essence of an engineering approac any discipline is that the components should be quantifia Whilst engineers will always be called upon to exerc professional judgement this clearly has to be distinguis from mere opinions. The first step in a total fire enginee approach is therefore to understand that there are vari aspects which go to make up fire safety and that they must quantified. Once the various elements contributing to design have been identified, it is necessary to define framework and a methodology whereby the influence of ea on the safety of individuals may be assessed.

6. STRATEGY

The overall strategy of the fire engineering design procedu

The analysis should be repeated for different times of day, different locations of ignition, different activities of the building, different arrangements of doors and windows, etc. The analysis may be done by hand calculation, or using fire growth computer models. In either case, detailed knowledge and experience of fire behaviour in buildings is essential. Large scale fire tests may be used in special situations as part of the fire engineering analysis.

8. FIRE ENGINEERING CALCULATIONS

Improved understanding of fire behaviour has dramatically increased the number of aspect of fire design that can be assessed by numerical calculation, including :

1. Fire growth and spread
2. Smoke production and movement
3. Occupant response, escape route design
4. Design of active systems
   - detection
   - sprinklers, water supplies
   - smoke control
5. Passive systems, structural performance
6. Fire spread by flame and radiation

Designers are encouraged to use computer based fire growth models for assessing the growth of fires to flashover. Such models permit calculations of times of response of detectors or sprinklers and the rate of lowering of the smoke layer leading to untenable conditions in the fire compartment. The severity of post flashover fires can be estimated on the basis of fuel load and available ventilation. This can be used to select fire resisting barriers on the basis of standard fire tests, or to make calculations of standard fire resistance from first principles. The fire resistance and permitted openings in external walls can be calculated using the expected fire severity. Smoke movement and control systems requir detailed analysis based on the interaction with the building heated, ventilating and air conditioning and security systen Mathematical modeling techniques are helpful i engineering design.

The availability of fast modern computing systems ha stimulated rapid development in the theoretical modeling c fire. Mathematical models based upon fundamenta principals of conservation of mass, momentum and energ are quite general in nature and once validated for thei application, these models can predict complete fir environment economically, within a reasonable time fram Mathematical model can also be used to examine th consequences of adopting alternative fire protection design Information on gas temperatures, species concentration, an heat fluxes to boundaries and occupants that can be derive easily by the use of mathematical models, is of great value i establishing engineered fire safety.

Mathematical modeling technique are generally divided int three categories : empirical or phenomenological method zone models and field models (Computational Flui Dynamics or CFD). The first category enjoys wide usage i the industry, and is perfectly adequate if the circumstances t which it is applied fall within the range of validity of its basi By the same token, application of this type of model outsid its range of validity can lead to major errors which are n always conservative. Zone models lie at the next level c complexity.

In zone modeling technique, the compartment is divided int a one or two zones, where conditions are assumed to b homogeneous and assumptions are made about the gro characteristics of fire. The mathematical equations a formulated based upon the fundamental laws of conservatio from the hot gas layer is absorbed by it. NEST has been developed to determine the operating time of sprinkler/detector fitted in enclosures.

12. CALTREE

CALTREE is a two layer pre-flashover model and employs quasi-static approach to provide an engineering approximation of time varying conditions created by fire in a compartment. It can predict temperature, interface height and neutral plane height. The model equations have been derived by the application of principles of conservation of mass and energy in the upper as well as lower layers. An interactive and user-friendly computer program, written in FORTRAN IV, has been developed, which computes the solution of model equation.

13. RELIEF

A mathematical zone model has been developed to predict the temperature of upper gas layer in the enclosure when lining materials along with source fuel, burns and contributes in the fire spread and growth in the enclosure. The lining material enhances the spread of fire and contribute in reaching higher temperature in the enclosure. So the lining materials are classified on the basis of the heat release rate potential in room corner tests as per ISO 9705. Depending upon heat release rates produced by the wall and ceiling lining materials in enclosure, temperatures can be predicted to design the fire protection system. For prediction of temperatures, a simple zone mathematical model named RELIEF (Risk Estimation due to Linings In Enclosure Fires) has been developed in CBRI.

Acceptable performance

A building is considered to have acceptable performance, if in the judgement of the design engineer:

1. the design of the building and the activities wit the building do not present an unreasona probability of fire occurring and
2. in the event of a fire, the following can be achie with a reasonable degree of certainty

a) all occupants will have adequate time to escape t safe place without being overcome by the effects the fire.

b) the fire service will have adequate time and suita access to undertake rescue operation and to prec property.

c) the fire will not spread to other fire cells within acceptable time

d) fire will not spread to adjacent household units a other property

e) significant quantities of hazardous substances v not be released to the environment

f) the contents of the building will not be seriou damaged

g) the building itself will not be seriously damaged

h) any damage to the building will be easily repairabl

14. CONCLUSION

Unwanted fires pose major risk to the safety to life a property in a built environment. India suffers a colossal l of over Rs 5000 million per annum on account of prope alone. In addition to this several thousand lives are lost du fires. Combined with the introduction of advanced syste of fire detection and suppression, there is a need to deve predictive tools for estimating the environment and measuring the performance of the fire safety systems.

Fire engineering, or fire safety engineering, is the applicat

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