



UNIVERSITI PUTRA MALAYSIA

**AN EXPERT SYSTEM FOR FIRE PREVENTION
IN HIGH RISE BUILDINGS**

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**AN EXPERT SYSTEM FOR FIRE PREVENTION
IN HIGH RISE BUILDINGS**

By

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**Thesis Submitted in Fulfilment of the Requirement for the
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Chairman: Ir. Dr. Mohamed Bin Daud

Faculty: Engineering

An expert system (ES) for fire prevention in high rise buildings was developed through a combination of interviews with domain experts and the statistical analysis of the thirteen years secondary data on the types and sources of fire breakouts in buildings from Department of Fire and Rescue, Malaysia. The problems related to fire prevention in high rise buildings, especially in the case of emergency and translation of the experts' knowledge into specific rules were analysed and incorporated into the ES. The stepwise regression analysis was used to test the data. The data and information were stored in databases and could be updated and referred through the ES. This program acts as an adviser for educating people who live in high rise buildings, so as to develop their awareness for better prevention of fire, or in evacuation process during an emergency. In addition, the ES helps fire engineers, architectures and managers in decision making on fire prevention designs based on the Uniform Building By-Law and available documentation.



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**SISTEM PAKAR PENGHALANG KEBAKARAN
DI BANGUNAN TINGGI**

Oleh

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Pengerusi: Ir.Dr. Mohamed Bin Daud

Fakulti: Kejuruteraan

Pembinaan Sistem Pakar untuk pencegahan pembakaran di bangunan tinggi dilakukan melalui temuduga dengan pakar dan menganalisa statistik data bagi 13 tahun. Data yang digunakan diperolehi daripada Jabatan Bomba. Masalah-masalah mengenai pencegahan pembakaran dan juga pengetahuan-pengetahuan yang diperolehi ditukar kepada peraturan untuk dimasukkan dalam Sistem Pakar. Data dan maklumat yang digunakan disimpan dalam pengkalan data. Sistem Pakar ini dapat bertindak sebagai penasihat kepada penghuni dalam masa kecemasan. Di samping itu juga ia dapat membantu jurutera-jurutera, arkitek dan pengurus dalam membuat keputusan mengenai pencegahan pembakaran berdasarkan “Uniform Building By-Law ” dan penyendikan yang telah dilakukan.



CHAPTER I

INTRODUCTION

General Background

The fire problem has recently become an urgent and important issue and there is a need to instill greater public awareness or consciousness. This is because fire can cause lot of damages to people. Fire in buildings is a major hazard to life, destruction to properties and loss of lives.

Accordingly, fire in Malaysia has become a matter of public concern. Moreover, fire is an uncontrolled combustion developing in space and it is still man's enemy in destroying things in its path. Based on these, this study focuses on the formulation of an expert system for fire prevention in high buildings in Malaysia. Assessment of fire cause factors, evaluation, prediction and prevention were made.

The overall objective of this study is to develop the Expert System for fire prevention in high buildings. This was done by using secondary data from the Statistics Division, Department of Fire and Rescue Malaysia and data from various sources. In particular, the expert domain and other sources were integrated with statistical analysis. Finally, this data was incorporated in the Expert System using rules in the form of IF and THEN.

Statement of the Problem

Many people deal with fire protection in buildings directly or indirectly. They include the architect who designs the buildings, the fire officer who is concerned with ensuring life safety, and the insurer who takes the risk of fire breakouts. Whilst there is a common aim among all concerned, their approach to the problem of fire protection varies in a number of respects because of their different functions.

The understanding of fire does not lend itself to one discipline. It requires basic knowledge of fluid mechanics, transport phenomena, and chemical kinetics to comprehend mechanisms that relate to fire technology. Fire and life safety can cover a wide spectrum of subjects ranging from chemical, building material, design and construction, safety codes, standards, and the design of various safety and emergency equipment.

In the present context of modernisation and the rapid advancement of industrial and building technology, it is also pertinent for us to be aware of the need to upgrade and to continually improve safety measures, and to absorb new or even radical approaches in the quest to protect lives and properties.

Destruction to properties and loss of life due to fire has of late, become a matter of public concern. Undeniably, these losses would have been greatly reduced

had more stringent fire safety measures been taken to prevent the occurrence of fire. Therefore great effort to improve the fire safety is needed. Without such awareness, efforts of fire prevention would be hampered and rendered ineffective.

Fire is one of the most common hazards or accident vectors encountered in the building. It is often accompanied by explosion. The outbreaks of fire are always dreaded. Even though a lot of publicity is given to incidences of fire in the mass media, they are forgotten soon after. Serious fires continue to occur several times each year causing great damage to properties and sometimes loss of life.

In Malaysia fire losses run into millions of ringgit annually. Fire has claimed many lives, caused injuries and extensive damage to properties and the environment. Between 1985-1997, the number of false fire alarms is 13249, the number of fire breakouts is 163,153, the number of deaths is 729, the number of injuries is 1045 and the estimated loss is 3,728,987 millions Ringgit Malaysia (Department of Fire and Rescue Malaysia).

Fires in high rise buildings are difficult for fire fighters to control and are dangerous. Occurrence of fire in an occupied office building during business hours is rare, due to the awareness of people. Fires in high rise building can be more difficult to manage as the number of building occupants is large and the large occupied area is within an enclosed space.

The hazard of fire is often defined as its potential to do harm to life and property. The vision of both victims and fire fighters is effected during fire, because of smoke most people get in such situation. During fire, the formation of Co is rampant as O₂ disoriented. It is the smoke and fumes in the gas that kill you, not the flame. Co is harmful and toxic. It is odourless and invisible. It can numb your brain, and kill you. Exposure to fire works for a long time in the night can rob your life and properties.

In order to prevent fire occurrences and the loss of lives, injuries and extensive damage to properties, it is important to educate the public. This study attempts to help people living in high rise buildings reduce occurrences of fire and to become more aware of fire hazards.

Objectives

The main objective of the study is to develop a tool to assist people on the prevention of fire in high rise buildings using an appropriate method. The specific objectives of the study are:

- 1) To extract opinions from selected people on main problems related to fire prevention.

- 2) To identify the main causes of the fire breakouts in many types of building based on statistical analysis of the fire breakout in buildings.
- 3) To develop a comprehensive Expert System for fire prevention in high rise buildings that could be used as a tool in assisting people to react to the fire incident. It is also used as an aid for fire engineer, architecture, managers and developers in terms of fire prevention.

Scope of the Study

This study concentrates on fire prevention in high rise buildings, in Malaysia. The causes of fire and its effects were included in all methods of fire prevention. The Expert System developed could only be used for fire prevention, in particular to assist the Prevention and Operation Division Department of Fire and Rescue in Malaysia.

Significance of the Study

The outcome of this study is an expert system that can be used for fire prevention in existing high rise buildings. It is very useful for providing fire education and fire prevention guidelines to the public.

By using an expert system on fire prevention in high rise buildings, people can understand the danger of fires and the sources of fire breakouts in different types of buildings. Then, they can protect themselves or improve their safety at home or at work from fire, and practice fire drills and react accordingly in case of such an emergency.

The Expert system can also provide fire instruction, and information to help the public to become more fire safe wherever they are. In addition, this expert system for fire prevention would become a very useful tool for the Department of Fire and Rescue in Malaysia in particular the Prevention and Operation Division. It can be used as a powerful tool for presentation and demonstration for fire hazard prevention and guide for emergency.

CHAPTER II

LITERATURE REVIEW

The Meaning of Fire

Fire can be described as the rapid oxidation of material undergoing combustion. For combustion to occur, fuel, oxygen and source of ignition must be present. Fuel, oxygen and source of ignition must be in contact before a fire can be started. These can be represented by the three sides of a triangle and fire can not start, or continue, if one of these is absent or removed (Anwor Sharif Bin Abdulllah, 1995; Goodger, 1977).

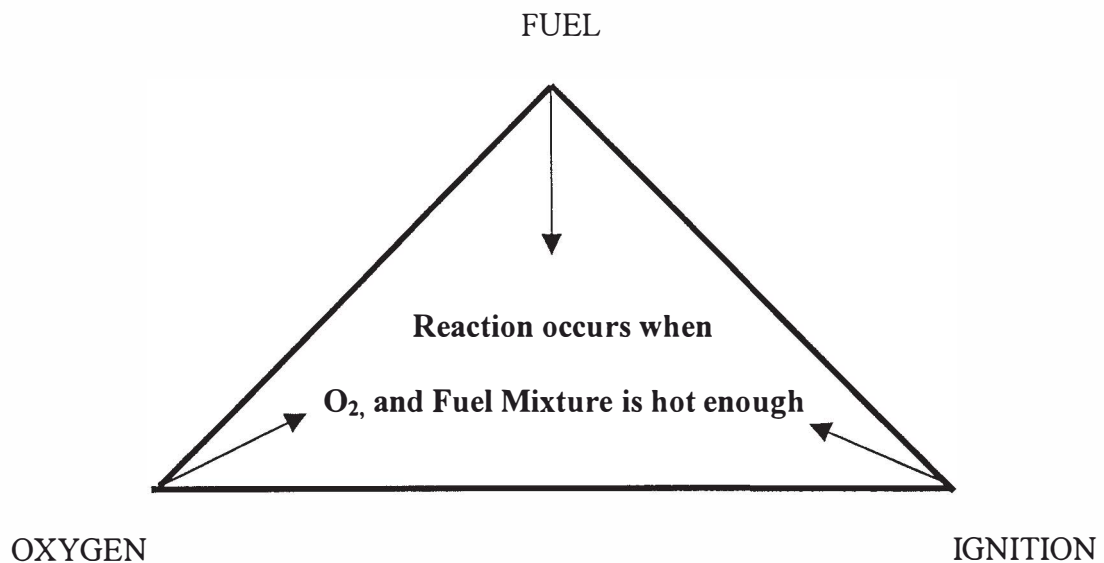


Figure 1: Fire Triangle

In the process of fire development, there are various types of fire propagation. Ignition in most fires is a process of transition from the input of heat to the stable propagation of thermal wave supported by heat release from combustion. It occurs only when there is initial heat input from an ignition source and is then followed by combustion reaction sufficient to establish a thermal wave (Zukoshi, 1986).

Ignition is the first stage of fire occurrence. Ignition characteristics such as ignition temperature, minimum ignition energy, and ignition delay time have been evaluated or measured (Toshisuke, 1993).

There are various types of heat sources in fires such as flame, hot gases, and heated walls. These heat sources characterise the fire behaviour and for practical purposes, the effects of heat sources on flame behaviour have been frequently examined instead of elucidating the heat and mass transfer processes (Harino, 1990).

Ignition refers to the appearance of a flame in the volatile gas stream evolved from a solid exposed to external ignition sources such as a flame or an electrical spark. It is classified as piloted ignition (Mahmood Abu-Zaid, 1993).

Fire Problems in High Rise Buildings

In high rise buildings a method of fire propagation to higher floors is via the outside of the building. The fire exits the incident floor through a window and spreads to higher floors as the flame and thermal plume rise through the effects of buoyancy (Nicole and Daniel, 1993).

Investigation of high-rise buildings constructed in the world is rapidly increasing. In building fires, flame and hot gases ejected from windows and flow along exterior walls may fracture glasses of upper floor windows and accelerate the fire growth into upward floors (Kunio Kuwaharam, 1993).

According to Stewart Kidd (1997) a number of common features that always place lives in danger are:

- 1) Unrestricted spread of smoke.
- 2) Late discovery of fire or late call to fire brigade.
- 3) Inadequate or obstructed exits.
- 4) Poor management of fire safety.

In the case of high rise buildings, the nature of the building not only aggravates the problem of exits but exacerbates the difficulty faced by the fire brigade in gaining access to the inside of the building and in getting enough water up to the level of the fire. There is no simple solution to fighting fire in high rise buildings, because each fire incident is unique and more problems are created in this type of structure. The multiple uses of high rise complexes, which can be houses, shops, offices, restaurants and some time hotels within one structure, compound the problem. Such buildings pose serious risks to life and properties. There are many potential causes of fire in the building. In apartment, hotel or office premises potential causes of fire is found in the combustible furniture and stationery. In a restaurant or shop premises, this is found in the combustible decoration, and in the articles displayed or goods

stored. A high rise building presents operational problems to fire fighters, as work has to be carried out within the confine of the building. The scale and magnitude of the problem rests largely on the occupancy, the layout and the design of the building, and whether this building is adequately equipped with fire fighting facilities (Arthur, 1988).

There have been a few spectacular hotel fires leading to serious life loss either in the sleeping area or in the public assembly area, which have become features of modern multi-storey buildings. Hotel fire creates special problems as most guests are temporary residents and are usually unfamiliar with the layout of the hotel and fire safety provisions. The sleeping occupants may not always react in the expected manner, as they are not alert and not in their normal environment (Malhotra, 1994).

Perhaps the most common fire hazard in high rise buildings is smoking, particularly in hotels where guests can be expected to go to bed and fall asleep while smoking without extinguishing the lighted cigarette completely. (Pallavicini, 1989).

Fire Prevention

The objectives of fire prevention are to prevent fires from starting, to prevent loss of life and property, to confine a fire to the place where it started and to extinguish the fire (Chelliah, 1988).

The prevention of fire in high rise buildings is not just someone else's responsibility, but the management's responsibility; and if fires are to be avoided, the management must become involved. Fire prevention therefore, should be the prime concern of the management top down. A fire protection plan should be formulated with a back up system to ensure that standards are being maintained. If loss of life or injury and the appalling financial fire loss that occur each year are to be reduced, it is vitally important that a high standard of fire prevention practices be implemented in all types of premises (Bamert, 1984)

There is a need for an adequate level of fire prevention to be provided as economically as possible. It must be stressed that the primary purpose is not to contrive savings but to ensure that the maximum benefit is derived from what is spent. In its capacity to effect both lives and livelihoods, debate on the approach and the priorities to be adopted in future must be considered (Tucker, 1994).

Active fire prevention and passive prevention are essentially man-based, working mainly through information, enforcement, regulation, education and motivation. Research and regulations are two forms of passive prevention. Research helps develop understanding of the causes and effects of fire and of the means of fighting it. Regulations encourage and enforce the adoption of a number of constructive rules or defensive measures in buildings which enforce staff training in fire prevention and fire fighting (Beaufort, 1984).

In considering the fire prevention life and properties of a building, the Architect or fire officer always tries to consider the building as a whole rather than separate components. But, of course, it is not always possible for the architect or officer to know the complete range of contents to be used in the finished building, or indeed, the end use of the building (Douglas Burns, 1984).

Fire prevention and fire fighting are probably as old as the phenomenon fire itself. Escape from fire has always been a prime concern, but its effectiveness depends on the surroundings. For it to be effective it is obvious has to be properly planned which entails the provision of sometimes expensive facilities (Graber, 1984).

Housekeeping

Housekeeping is a word often used by fire prevention officers since many fires have occurred as a result of bad housekeeping. A high standard of housekeeping and good storage practices are essential to the prevention of fire spread (Hom and Karter, 1981).

Housekeeping to prevent fire is a combination of diligence, patience and common sense. Housekeeping to prevent fire is not the exclusive purview of the building maintenance department. Rather, it begins with the habits of every employee. Maintenance should take the lead in defining and promoting housekeeping requirements (Sheldon and Fuchs, 1992).

Fire Drills

The responsibility for carrying out fire drills rest on the manager of the premise. A fire drill is intended to ensure, by means of training and rehearsal, that in the event of fire. Building occupants act in a calm and orderly manner to the refuge area. Those designated carry out their allotted duties can do their work effectively to ensure the safety of all concerned (Soh Chai Hock, 1993).

According to Stewart Kidd (1997) fire drills in high rise buildings should be carried out every 12-months. Drills should be based on the assumption that one escape route cannot be used during fire especially when there are alternative routes. During drills member of staff should operate the fire alarm and thereafter, the routine should be rehearsed as full as circumstances allow. Advanced notice of the drill will normally ensure goodwill and minimise any disruption or anxiety, when the fire alarm is on.

In Malaysia, fire drills is mandatory and has to be carried out at least twice a year. The advantages of having fire drills are as follows: 1) Helping personnel know what to do in the event of fire. 2) Fire can be easily controlled or extinguished at its incipient stage. 3) Instil better understanding of fire prevention and fire procedures. Telephone operators, supervisors and building maintenance supervisors must be able to understand the function of switches, panels and other fire protection gears installed in the control centre and able to react correctly in the even of fire (Badarudin, 1994).

Enforcement

Enforcement to regulate people is a valuable tool in fire prevention work. It is absolutely necessary to use it if fire hazards are to be effectively controlled. The enforcing authority must have sufficient authority to deal with incendiaries, building contravention or occupancy and factor affecting public safety. Courts have upheld many actions taken under this policy such as making it mandatory to install automatic sprinklers in buildings (Chelliah, 1988).

Building regulations are statutory instruments, which set down minimum requirements for the design and construction of buildings. Minimum requirements are established to safeguard the health and safety of society and generally represent a compromise between optimum safety and economic feasibility. Building developers can also establish their own requirements, which may exceed the minimum requirements of the building legislation. Performance-type regulations should specify the objectives to be attained and criteria for determining if established objectives have, in fact, been met. The main purposes of fire safety legislation to impose a level of fire safety such that it is unlikely for people occupying a building to suffer injuries in the event of an unwanted fire, and to protect the community at large from the consequences of fire in an individual building. Thus, the tactics of fire prevention and fire protection will be incorporated into fire safety legislation with differing degrees of emphasis. It may be simply stated that the current fire safety legislation reflects the loss through fire of both life and property which society is prepared to accept or tolerate (Shields and Silcock, 1987).