THE DEVELOPMENT OF A FIRE SAFETY EVALUATION PROCEDURE FOR THE EDUCATIONAL ESTABLISHMENT

By - MOHD FADZIL MOHD IDRIS B.Sc., M.Sc.

A thesis presented for the degree of Doctor of Philosophy

VOLUME ONE

Department of Civil and Environmental Engineering
The University of Edinburgh

October 1997
In the Name of ALLAH the MOST GRACIOUS and the MOST MERCIFUL

To my beloved family, wife and son.
DECLARATION

This thesis has been prepared and composed by the author himself under the supervision of Dr. E.W. Marchant, unless otherwise stated, from the research work undertaken in the Department of Civil and Environmental Engineering, the University of Edinburgh, for the degree of Doctor of Philosophy.

Signature,
ACKNOWLEDGEMENTS

The author would like to express his greatest gratitude to Dr. Eric. W. Marchant, Department of Civil and Environmental Engineering, the University of Edinburgh, for the encouragement, supervision, guidance and advice given by him throughout the study. The author also wishes to thank the following for their valuable support and time during the study. Without their sincere assistance the study would not have been feasible and successful.

Dr. Dougal Drysdale - for guidance and advice (2nd Supervisor)

Ministry of Education, Malaysia. - for granting the permission, approval and support of the survey to be carried out within their authorised premises (the schools and universities).

Vice Chancellors - for their support, assistance and valuable time in carrying out the survey within the university premises, and also to thank all the staffs and students who has been participating in the survey.

Headmasters - for their support, assistance and valuable time in carrying out the survey within the school premises, and also to thank all the staffs and students who has been participating in the survey.

Dean and Staffs of the School of Housing, Building and Planning, USM. - for helping with the distribution and collection of the survey questionnaire in Malaysia.

The Fire Brigade Head. Office, Malaysia - for their assistance, the information and allowing access to their library.

The Delphi Group1 - for participating in the group discussion (Mr. Amir, Mr. Isham, Dr. Mohd Basir, Dr. Md. Som, Dr. Ismanizan, Dr. S.Hussien, Dr. Dzul Haimi and Dr. W. Mohd Naim).

Mr. Graham Poole - for the time and explanation on the PROBE.

The author would also please to thank Mr. Mohd Shamzan (my brother), Mr. Mohd Aris (MSD), Mr. W.A Saifuluddin, En Rosli (BOMBA), Mr. M.Kamil Arshad & family, for helping with the information gathering from Malaysia. Many thanks also forwarded to all the colleagues of the Group of Fire Safety Engineering, the Department of Civil and Environmental Engineering (representing the Delphi Group2) including the overall Malaysian community in Edinburgh for their generous assistance and encouragement which are highly appreciated.

To the Malaysian Government, the author thanks you for the financial support and trust.
ABSTRACT

With this research, the author hopes that he will be able to convince the Malaysian government to emphasise the importance of fire safety within schools and other government buildings within the government estate which should be given serious consideration for upgrading the fire safety provisions. Consideration should be given also to the application of the building laws and regulations not only to government buildings but also to private property.

There are four major approaches in dealing with the development of the evaluation procedure. They are as follows:

A) Questionnaire - survey search. This was conducted to gain information on the quantitative and qualitative data appraisal. Among the important aspect of conducting these survey is to know or to establish a general reference on occupancy awareness towards fire safety within the educational establishment. These include: the background of the occupants, training conducted, knowledge on fire fighting and extinguishing, escape routes and procedures, rules and regulations within the premises and management considerations. Besides, the areas of interest, information on the fire safety equipment available and the risk assessment procedures was also obtained. This will ease the implementation of the evaluation procedures according to the existing and future requirement of fire safety in educational establishment. These are based not only on professional judgement but also from the point of views or considerations of the occupants.

B) Professional Judgement - Loss impact, importance and qualitative appraisal plus the formation of the organisational body for getting the fire safety requirements and perspectives into action. Delphi group was formed. The involvement of professionals with different expertise and knowledge backgrounds based on their interests was valuable. The selected members represented the Malaysian population (in theory) in terms of their perspectives and knowledge or judgement on fire safety conditions and requirements in secondary schools or the educational establishment as a whole. A set of questions and answers were given for the members to choose and discuss. The whole process was conducted through several meetings organised by the researcher. Among the findings was the loss impact caused by the removal of different buildings within a certain community. But the most important is the effects of school fires to the community around it and also the loss impact to the local, national and international levels. A quick reference and advice can be given by the Delphi check list to be used by professionals and administrators in dealing with fire in buildings particularly to the schools. The policy, objectives, tactics, components and sub-components of fire safety have been introduced to cater the need of fire safety within the educational establishment. The outcome then can be used to produce the check list and procedure for the fire safety evaluation of the educational establishment in Malaysia. These procedures will have to be tested with the local schools in Malaysia or within the U.K to see the utility and effectiveness of the whole operation.
C) **Check List and Fire Safety Procedure** - A points scheme method to evaluate the Educational Establishment is introduced. The study has been referred to the evaluation of fire safety scheme used in Hospital Patient Areas (Scotland), Dwelling Houses and the Industrial Buildings (Probe). The evaluation points scheme check list can be used to evaluate the existing educational buildings and perhaps new buildings regarding their adequacy in terms of fire safety provision. This referred to the acceptable safety standard based on the building regulations or Building By-laws 1984, Laws of Malaysia and also the agreement and consensus given by the Delphi group members. There is also another check list which can be used to evaluate the performance of each of the safety systems within the building either they are contributing toward the acceptability standards or not. This will assist in the process of upgrading and improving the current safety condition of the building areas or the building as a whole by replacement, alteration or Trade-off methods.

D) **The Experimental Approach: To Investigate The Optimal Location for Smoke Detectors**. The approach that will be tested:

   i. Non Ventilated Areas or Space.

The experiment is to find out the variation of smoke detector performances caused by the degree of inclination or steepness of the roof or ceiling, the sizes of space and height of the areas. Both are physical models based on a standard building plan of a Malaysian School designed in a module system for easy expansion or change in the use of areas. However, a roof of different pitch angles was introduced and with the flexibility of the physical model it is hoped to show that with various angles of roof/ceiling may suggest a new ways to improve the effectiveness of the smoke detectors in terms of their location on the roof areas or ceiling. The advantages of installing smoke detectors may be sufficiently convincing to pressure the general public of their value. The experiment is based on the heat produced by a rubbish bin fire (to a scale 1:20) and using K-type thermocouples as the smoke detectors. The optimal location of the sensors was based on the response period within 5 minutes of exposure. The trends of smoke movement within the model based on the various compartmentation sizes and volumes may help engineers to make decisions about the possible optimal location for detection or suppression systems heads to be installed on to the ceiling or within roof voids. This will probably help to increase the performance of the systems and allow the achievement of the fire safety objectives with more confidence.
Foreword

Fire has been known to man for its usefulness and destructiveness of human activities. Fire is well known for its capability to provide heat and yet when it is out of control or beyond human supervision, it can caused loss of human life and also property. This is why the importance of fire safety started to be acknowledged by other professions. Several studies and research have been undertaken for more than half a century trying to solve the problems created by fire. Man will have to find the best and optimal solution to apply the technology of fire safety. This should be implemented in a positive way to create a fire safe environment but an environment where the challenge of fire is ever present. Not only that, human beings will also need to learn and understand much more clearly the ways to react when confronted with a fire situation and its threat at all levels of exposure. It is the awareness about fire safety and the danger that exists around the human environment need to be established. This is very important as the dynamic force of a fire can do all kinds of harm to people and property.

Fire is not something new in human life. There is always some benefit and disadvantage when dealing with fire. People have been told about the danger of fire and associate something bad with fire for a very long time. There are verses in the Al-Quran that stated how man first produced fire, it is translated as:

"The same Who Produces For you fire out of (4026). The green tree, when behold! Ye Kindle therewith (Your own fires)!” (Surah Yassin : Ayat 80)

“Even older and more primitive than the method of striking fire against steel and flint is the method of using twigs of trees for the purpose. In the E.B., 14th edition. ix. 262, will be found a picture of British Guiana boys making a fire by rotating a stick in a round hole in a piece of wood lying on the ground. The Arab method was to use a wooden instrument called the Zinad. It consisted of two pieces to be rubbed together. The upper one was called the Afar or Zand, and the lower the Markh. The markh is a twig from a kind of spreading tree, the Cynanchuin viminalis, of which the branches are bare, without leaves or thorns. When they tangled together, and a wind blows, they get ignited and strike fire (Lane’s Arabic Lexicon). In modern Arabic Zand is by analogy applied to the flint piece used for striking fire with steel.”

Fire safety is getting serious attention from every individual or organisation. The works and studies in this subject are widening and broadening further along with the advance of the technology. Several evaluation studies have been undertaken to evaluate the level of fire safety performance within buildings such as hospitals, factories, historical buildings and dwellings involving the installation, efficiency, practicality, cost benefit and reliability of the fire safety system within areas in a building. The work is to ensure that the previous or current fire safety standard proposed for the safety of the human life and building property and other objectives are being achieved. However, there are so many areas of fire safety that need to be considered in order to reduce the growing numbers of fire disasters in our demanding and developing world.
Preface

This study involves all aspects of the standards for Fire Safety Requirements and the evaluation of the building performances regarding fire. The focus is on the educational establishment in Malaysia, particularly the secondary residential schools. The importance of having fire safety personnel, awareness, knowledge and technology in the buildings is established beyond doubt in all the countries around the world. Fire disasters are happening everywhere and it needs to be prevented from spreading any further and the number of accidents reduced. Since the children are our leaders of tomorrow, we need to provide them with adequate provision in education. Up to date school buildings are important for them to gain as much knowledge in a safe and comfortable environment. There are few cases involving school children whom caught in fire disaster while being at schools. Losing them is considered to be a tremendous loss to mankind. There are many schools with different orientation and backgrounds which provide education to the young. Some schools are being sponsored by the government and some are being operating privately by an individual or private organisation but approved by the Ministry of Education in Malaysia. As there are differences involving management, administration and approaches in budget allocation. These differences have caused the development and condition of those schools to be inconsistent. Therefore, steps need to be taken in order to cater for the problems of inconsistency and this research is very particular in tackling the aspect of fire safety problems within the residential school buildings for the future education development in Malaysia. The study has incorporated the pupils behaviour and level of awareness, professional perceptions and opinions, technology availability, building regulations requirements, fire risk assessment, fire engineering designs and also qualitative appraisal using the points scheme for the evaluation of the fire safety performances in educational buildings. The fire safety engineering design development application is focused on the investigation of the smoke detector optimal locations. The fire safety requirements are based on both the Malaysian Standard and British Standard which are widely being used in the construction purposes in Malaysia. Some comparison between them are very important as the climatic situation in Malaysia is totally different compared to the United Kingdom. All these have formed the fire safety evaluation procedure for the educational establishment in Malaysia particularly the residential secondary schools.
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1.0 Introduction

Fire safety is always a serious matter to every individual or organisation. Perhaps the works and studies in this subject are widening and broadening in parallel with the advancement of the technology. Several evaluation studies has been undertaken to evaluate the level of fire safety performance i.e. installation, efficiency, practicality, cost benefit, etc. of certain areas in a building (2). This is to ensure that the previous or current fire safety standard proposed for the safety of the human life and building property and other objectives being achieved. However, there are still a lot of other areas of fire safety that need to be considered in order to cater or maintain and even reduce the growing numbers of fire disasters in our demanding and developing world.

Children are our future leaders. Governments are very concerned about education and welfare, This is shown by the allocation of huge financial and human resources to the provisions of adequate educational buildings or institutions. To ensure adequate facilities is to cater the growing need and number of young intellectuals with comfort, educational aid, services and teaching and learning facilities. In Malaysia particularly, fire hazard problems still exist. The 1992 and 1993 statistics on fire accidents show the following:-

<table>
<thead>
<tr>
<th>Category</th>
<th>1992</th>
<th>1993</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Loss in RM (million)</td>
</tr>
<tr>
<td>Buildings</td>
<td>2276</td>
<td>-</td>
</tr>
<tr>
<td>Vehicles</td>
<td>883</td>
<td>-</td>
</tr>
<tr>
<td>Forest/ Scrub</td>
<td>7838</td>
<td>-</td>
</tr>
<tr>
<td>Others +</td>
<td>4012</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>15,009</td>
<td>425,643</td>
</tr>
</tbody>
</table>

Note: (+) Others refer to machinery, equipment, petrol/chemical/gases etc. (3)

Table 1.0: The 1992 and 1993 statistics on fire accident in Malaysia.
The fire accidents involving buildings are increasing in number, eventhough the total number of fire accidents for 1993 show some sign of reduction but the total loss in Malaysian currency (RM) is getting even higher. The nightmare of fire seems to be greater each year, involving children and educational buildings and preventative steps must be taken seriously. There are a few cases involving school children whom were caught in a fire disaster while studying at a full boarding schools. Losing them is a tremendous loss to mankind. In order to understand the real problems faced by the school in terms of fire safety, several stages such as design, planning and construction, legislation, administration, financial, human behaviour and any other check list that contribute towards the evaluation of fire safety needs to be obtained. Proposed standards for construction and design including the fire safety engineering techniques available will be applied parallel to the research findings which hopefully can improve the future design and safety of schools and other educational establishments.

1.1 Serious Fires in Educational Establishment

Incidence of fire in educational establishments has caused a lot of damage and loss including property and other valuable items but the most of all - human lives. Small fires can be our friend but it can also become our most dangerous enemy when it is out of control.
In 22 September 1989, a private Religious School of Taught, Taufiqiah Khairiah Al Halimiah in a village known as Kampung Padang Lumat, Alor Star in the state of Kedah, Malaysia, an unexpected fire disaster occurred and it caused great loss of human lives (the children). It also damaged the whole of the wooden hostel blocks. It was the worst fire tragedy in the country. It was reported that; 27 (girls) aged between 13 and 16 died in an early morning fire which engulfed 8 wooden hostel blocks and 6 more were admitted to the general hospital. However, many others were given out-patient treatment.

<table>
<thead>
<tr>
<th>Name of School/Institutions</th>
<th>Loss/ Damages</th>
</tr>
</thead>
</table>
| Madrasah Taufiqiah Khairiah Al Halimiah Padang Lumat, Alor Star Kedah, Malaysia. (22 September 1989) | Building: 8 wooden hostel blocks  
Building Area: Sleeping area  
Hostel Block Size: 18 x 6.6 metres  
Fire break out time: 01.50 hr.  
Died: 27 girls  
Injured: 6 (serious) many others (out patient)  
Age: 13 ---> 16 years  
Cause of death: Falling beams & roof structure. Bad interior layout/ (Ergonomic) closely arranged to take 80 to 100 pupils. Suffocated with smoke/ heat Insufficient numbers of exit. |

Following are other examples of the fire hazard accidents involving the educational establishment.

<table>
<thead>
<tr>
<th>Name of School/Institutions</th>
<th>Loss/ Damages</th>
</tr>
</thead>
</table>
Estimated: RM$ 80,000 (£20,000) |
| Universiti Pertanian Malaysia Serdang, Selangor, Malaysia. (20 January 1989) | Time: 20.30 hrs  
Building: 1 hostel block  
No Death but 100 pupils lost shelter. |
| Sekolah Menengah Sri Inai, Jalan Park, Georgetown, Penang, Malaysia. (16 February 1989) | Time: 02.30 hrs  
Building: Hostel (private)  
Died: 3 students  
Injured: 11 (serious)  
Estimated: RM $ 200,000 (£50,000) |
| Sekolah Rendah Jenis Kebangsaan (Cina) Chung Hwa, Serom Tiga, Muar, Johor. (22 February 1989) | Time: 16.40 hrs  
Building: 4 classroom, canteen and a store.  
Estimated: RM $ 100,000 (£25,000) |
Building: Assembly hall  
Estimated: RM$ 100,000 (£25,000) |
Building: Hostel block
80 students lost shelter
Estimated: RM $100,000 (£25,000)

Time: 0.30 hrs
Building: Education and Technology Media Centre.
No death.
Estimated: RM $7 million. (£1.75 million)

Malaysian local Newspapers and Malaysian Fire Brigade (Bomba) 1989. (4)

All the above mentioned were amongst the several fire accidents happened within the year 1989 (January until May) in Malaysia involving the educational establishment and the lost was estimated about RM $8 million (£2 million). Types of building areas that are most in favour of fire hazards were hostels (sleeping area) followed by classroom, canteen, store room, resource and technology media centre and assembly hall. However, the consequences of fire hazard accidents within the educational establishment shows that every single part of the building areas are vulnerable to fire. Further information regarding fire accident from year 1988 until 1993 within the educational premises in Malaysia can be obtained from the table below.

<table>
<thead>
<tr>
<th>Year</th>
<th>Electric Cigarette Butts</th>
<th>Spark (Fire)</th>
<th>Firework Coils</th>
<th>Mosquito Stove</th>
<th>Gas/Oil Spontaneous</th>
<th>Arson</th>
<th>Not Chemical</th>
<th>Matches</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>6</td>
<td></td>
<td></td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>14</td>
<td></td>
<td></td>
<td>4</td>
</tr>
<tr>
<td>1989</td>
<td>17</td>
<td></td>
<td></td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>14</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>1990</td>
<td>17</td>
<td>3</td>
<td>-</td>
<td></td>
<td></td>
<td>3</td>
<td>18</td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>1991</td>
<td>16</td>
<td>2</td>
<td></td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>16</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td>1992</td>
<td>12</td>
<td>2</td>
<td>1</td>
<td></td>
<td></td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>16</td>
<td>2</td>
</tr>
<tr>
<td>1993</td>
<td>11</td>
<td>2</td>
<td></td>
<td></td>
<td>3</td>
<td>2</td>
<td>9</td>
<td>18</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>79</td>
<td>9</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>14</td>
<td>5</td>
<td>27</td>
<td>96</td>
<td>4</td>
</tr>
</tbody>
</table>

Note:- Statistic given by the BOMBA (Malaysian Fire Brigade Force)(2)

Table 1.1: Statistic On Sources Of Fire Within School/ Institute/ Hostel From 1988 Until 1993

4
1.2 Source of Fire

Generally source of fire accident in building can be of any deliberate ignition, electrical failure, human error, bad maintenance, unknown sources and also natural causes. In Malaysia, the Table 1.1 above shows the sources of fire in educational establishments for the period of 1988 until 1993. The slight difference compared to the UK statistical information compiled by Katherine Scoones (5), are only the fire works and mosquito coils which are not common in the UK. However in the last 10 years, fire occurrence in the educational establishment has shown a great increment. Therefore, it is very important to investigate the source(s) of ignition when assessing a building. The information gathered through fire statistics from survey research or fire brigade reports could help the management and authorities or policy makers to provide the fire safety necessities to the level or standard required in terms of guarding the buildings and it's occupancies. Once the source of fire is established, the management team can focus on some problems and solve them either by upgrading the security level, maintenance of the electrical wiring and equipment, improve the level of fire safety awareness among the occupancies or, may be, improve the provision of fire safety components within the buildings. In order to do this, a proper fire safety evaluation procedure for a building will need to be available so that the fire problems can be tackled thoroughly from the basic occupancy up to the management or authority level.

The questions that can be asked are:--

a. What is the level of security available?
b. What is the level of fire safety awareness among the occupants?
c. How well is the building(s) and it's contents including the services being maintained?
d. What level of performance that is expected from each of the fire safety provisions within the building?
e. What are the "unknown" sources of fire?
f. How can the fire sources caused by natural or human error be reduced or eliminated?
g. How safe is the building?
There are many other questions that can be proposed in order to find the loop holes of the fire problems and ways of solving them. That is the reason why, fire risk and fire safety within the building should be investigated. In this study, the whole process of producing the fire safety evaluation procedure for the educational establishment is being explained in section 1.5. And the risk and safety assessment will be tackled directly and indirectly in Chapters 4, 5 and 6.

1.3 Fire Casualties

The loss of human lives can never be replaced by any other means. Data has shown that fire accidents cause amongst the highest number of fatalities compared to the other kinds of accidents such as falls, motor vehicles and machinery. The fatal accidents often caused by severe burns, inhalation of smoke or other toxic gases, unconsciousness and entrapment, struck by a heavy object or obstructed escape. "Such data provide a valuable mechanism to continually assess the effectiveness of fire protection measures, including public education campaigns, research and new technologies, refinement in fire codes and standards, and automatic detection and suppression equipment" (6). Overall, Malaysian student awareness may be at a slightly lower than in the UK if we compared with the number of fatalities. But, the fatalities number may be referred to a single accident where a group of people within the room or building were trapped and caught in fire during sleeping hours. Normally deaths resulting from sleeping accommodation were caused not by the fire but because the victims probably died earlier as they inhaled or suffocated with the degree of smoke gases present within the room.

H.L. Malhotra(7) said that human reaction to such hazards depends upon the duration and the condition of exposures. Smoke and gases developing gradually from a decomposing chairs or a bed if inhaled in low concentrations over a long period can adversely influence the responses of a person to danger. Sudden exposure to high concentrations of hot, toxic and oxygen deficient gases i.e. when opening the door of a room on fire, may incapacitate in a fairly short time. Purser (8) has classified the fire atmospheres into two broad types:-
a) Atmospheres containing narcotic and potentially toxic concentrations of CO and/or HCN, (capable of leading to fatalities) and

b) Atmospheres containing high concentrations of irritants and/or particulate matter (causing problems with orderly escape).

This has been confirmed by H.L. Malhotra(7) that in general, the main victims of bedroom fires are the occupants within the room. Currently 2/3 of fatalities and 1/5 of injuries are caused by fire gases. It has also been suggested that the increasing role of fire gases is related to the increasing presence of synthetic materials as contents of buildings and for furnishing purposes.

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of Fire Accident</th>
<th>Death</th>
<th>Injured</th>
<th>Total Loss (RM $)</th>
<th>Total Recovered (RM$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>29</td>
<td>-</td>
<td>-</td>
<td>953,000</td>
<td>1,673,000</td>
</tr>
<tr>
<td>1989</td>
<td>45</td>
<td>31</td>
<td>16</td>
<td>7,783,000</td>
<td>23,882,000</td>
</tr>
<tr>
<td>1990</td>
<td>50</td>
<td>-</td>
<td>-</td>
<td>8,676,000</td>
<td>13,035,000</td>
</tr>
<tr>
<td>1991</td>
<td>50</td>
<td>-</td>
<td>3</td>
<td>2,112,000</td>
<td>731,000</td>
</tr>
<tr>
<td>1992</td>
<td>49</td>
<td>-</td>
<td>1</td>
<td>4,743,000</td>
<td>5,723,000</td>
</tr>
<tr>
<td>1993</td>
<td>53</td>
<td>-</td>
<td>2</td>
<td>3,153,387</td>
<td>19,301,734</td>
</tr>
<tr>
<td>TOTAL</td>
<td>276</td>
<td>31</td>
<td>22</td>
<td>27,420,387</td>
<td>64,345,734</td>
</tr>
</tbody>
</table>

Note: - Statistic given by the BOMBA (Malaysian Fire Brigade Force)(3).

Table 1.2: Fire Statistic Within School/Institute/Hostel From 1988 Until 1993

There also have been a significant number of fire accidents within some parts of the world such as in the UK. The statistics are shown below.
Table 1.3: Comparison of fires incurring losses of 50,000 pounds sterling plus in educational establishment with all fires over the years 1986-1991

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of serious fires in educational establishments</td>
<td>107</td>
<td>95</td>
<td>85</td>
<td>112</td>
<td>143</td>
<td>128</td>
</tr>
<tr>
<td>Number of fatalities</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Total losses due to serious fires in educational establishment (Pounds Sterling)</td>
<td>34,157,000</td>
<td>24,749,000</td>
<td>21,970,000</td>
<td>36,028,500</td>
<td>50,368,164</td>
<td>50,718,000</td>
</tr>
<tr>
<td>Total number of all serious fires</td>
<td>1242</td>
<td>1152</td>
<td>949</td>
<td>1045</td>
<td>1065</td>
<td>1053</td>
</tr>
<tr>
<td>Total losses for all serious fires</td>
<td>36,439,850</td>
<td>32,986,825</td>
<td>39,319,175</td>
<td>29,491,943</td>
<td>36,606,513</td>
<td>417,971,384</td>
</tr>
<tr>
<td>Number of serious educational establishments fire as a percentage of all serious fires</td>
<td>9%</td>
<td>8%</td>
<td>9%</td>
<td>11%</td>
<td>13%</td>
<td>12%</td>
</tr>
<tr>
<td>Loss due to serious educational establishment fires as a percentage of all serious fires</td>
<td>9%</td>
<td>8%</td>
<td>6%</td>
<td>12%</td>
<td>14%</td>
<td>12%</td>
</tr>
</tbody>
</table>

Source: Katherine Scoones, "Serious Fires in educational establishments during 1992", (5).

**Name of School/Institutions** | **Loss/ Damages** | **Cause**
---|---|---
1. Stockport Secondary School, Cheshire (19 May 1992) 1938 hours | Classroom Block Estimated: £ 850,000 | Arson
2. Ponteland High School, Tyne and Wear (29 Dec. 1992) 0203 hours | Chemistry laboratory Estimated: £ 250,000 | Arson
3. Treherbert Youth Centre, Mid-Glamorgan (23 March 1993) 1912 hours | Gymnasium Store Matt Estimated: £ 400,000 | Carelessly discarded smoking material.
4. Belfast Grammar School (19 Oct., 1992) 0145 hours | 6 classroom Estimated: £ 400,000 | Arson
5. Welton Secondary School, Lincolnshire (24 May 1992) 0842 hours | 2-storey science block Estimated: £ 500,000 | Arson
6. Wallsend Middle School, Tyne and Wear (20 May 1992) 2251 hours | Assembly hall/Dining/Gym Estimated: £ 427, 500 | Arson
7. Sheffield Middle School, South Yorkshire (4 June 1992) 0026 hours | Community Centre/Classroom Estimated: £ 300,000 | Unknown
8. Everton High School, Liverpool (18 Sept. 1992) 2204 hours | Staff room/Classroom/Kitchen Unit Estimated: £ 562,000 | Arson

(Compiled by Liz Catchpole, 1993)(9)

A lot of the fire incident in schools happened during rest hours between 1800 to 0600 hours. All areas within the school premises seem to be vulnerable and
exposed to danger of fire either caused accidentally, carelessly or by arson. The attack by arsonist seems to becoming more frequent. Improved security would probably be the best way to reduce the problem but needs to be confirmed. Therefore, both security and fire safety will need to be considered in this study.

<table>
<thead>
<tr>
<th>No. of fires</th>
<th>Occupancy</th>
<th>Loss in £ m</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1993</td>
</tr>
<tr>
<td>52</td>
<td>Retail distribution</td>
<td>29.0</td>
</tr>
<tr>
<td>46</td>
<td>Educational establishment</td>
<td>22.2</td>
</tr>
<tr>
<td>22</td>
<td>Wholesale distribution</td>
<td>19.9</td>
</tr>
<tr>
<td>16</td>
<td>Textiles</td>
<td>17.7</td>
</tr>
<tr>
<td>17</td>
<td>Food, drink and tobacco</td>
<td>13.4</td>
</tr>
<tr>
<td>31</td>
<td>Recreational and cultural services</td>
<td>7.3</td>
</tr>
<tr>
<td>11</td>
<td>Chemical and allied industries</td>
<td>6.9</td>
</tr>
</tbody>
</table>

Table 1.4: The seven occupancies suffering the largest losses for 1993(UK)(5)

In table 1.4, if the comparison given from the above statistics, educational establishment fires are the second highest contributor to the estimated loss for year 1993 and it was the same rank given to the educational and institutional fire which causing large loss of life in the NFPA 15th edition from the year 1900 until 1980(10).

Therefore, a serious consideration should be taken to cater the problems facing by the educational establishment in terms of fire safety. A checklist to evaluate the safety standard of the educational establishment will need to be introduced in order to identify and subsequently reduce the number of fire hazards and mainly to provide a safe and comfortable place for the children of our future generation. The pupils also need to be provided with adequate knowledge and training in fire safety to help influence the intellectual and social development of the nation to build a safer environment. The evaluation checklist is introduced in the Chapter 7 and Chapter 8.

1.4 Fire Safety and It's Role

Fire accidents have been the major contributor towards the loss of lives and property. Not only that, fire also causes other loss in terms of economy, time
wasted or distraction for the continuity of mission, pollution of the built environment and it's surroundings. All the loss factors mentioned have resulted some interest among the individuals or professionals to focus on solving the problems in confronting the unwanted fires and their threat in all the premises where human life is the main objective to be safe from the fire. In order to sustain the safe environment, man has tried and still trying to create the fire safe environment and reduce the rate of loss through fire with the help of several organisations or bodies such as the fire brigade, police, professionals (including building designers, contractors and engineers), local authorities, researchers and individuals. The technical and social challenges of preserving our well being and property with the forces of economy has put on pressure for these fire safety bodies to erect the adequate defences against fire threat, if not to eliminate the danger, at least reduce it to an acceptable level by definition. One needs to know that the design, construction and management of buildings is not a static science or art but yet it is a dynamic activity which produces major problems for the fire safety engineer especially in buildings of increasing geometrical complexity, those which contain multiple uses and occupancies in an atmosphere of managerial and technological change.

In order to address the fire problems within educational establishment buildings, particularly the Fully Residential Secondary School, a collective measure in terms of fire safety and the types of buildings will need to be established. The fire safety interest is creating a fire free environment inside and outside the buildings. Therefore, the approaches and disciplines to counter the problems of fire within the establishment will be dealt by:-

a. Fire Safety Knowledge- awareness, science, training and rescue.
b. Fire Safety Engineering- fire fighting, fire suppression (protection and prevention)
c. Fire Safety Management- costing, installation, planning, decision making, priority, quality assurance.
d. Fire Safety Evaluation- hazard, risk, safety, performance, acceptable, adequacy.
e. Fire Safety Design- the optimal arrangement of spaces, materials and systems.
If there is no worry of financial allocation for the fire safety system to be installed within a building, quality of the product and performances will become the most prominent factor that influences purchasing decisions. Not only that, the management bodies will ensure that the money spent on those fire safety components buy the best performance for predicted fire emergencies within the system. This part of fire safety engineering deals mostly with management and quality assurance.

1.5 Legislation and Enforcement of Fire Safety Requirement

There are several bodies or organisation that have helped to develop and advance fire prevention and protection measures. Among them are the National Fire Protection Association (NFPA), insurance service organisations, fire testing and research laboratories and certain government agencies. There are a lot of Acts and legislation that have been set by local authorities in order to cater for fire hazards in buildings. In Malaysia, the requirements of legal actions, especially regarding fire safety, will involve the following authorities:-

1. Fire Services Departments or Fire Brigade Forces (Bomba)
2. Insurance Companies

The role of each authority on fire safety for buildings are very important to look at because it is a part of prevention measures. There are 3 methods of specifying legislative requirements and often a mixed system is employed (11):-

i. *In a functional system*: the aims or objectives are specified and the designer or architect can by reference to explanatory notes and guides or codes provide evidence that the objectives are being achieved.

ii. *In a performance based system*: the objectives are translated into specific performance levels to be achieved in appropriate tests or through measurement by evaluation techniques.
iii.  *In a prescriptive system:* precise details of construction or permissible system are given, which may possibly be specified on a deemed-to-satisfy basis.

The author has carried out research for educational establishments in terms of fire safety evaluation based on the system (ii) above to see whether the existing school buildings are safe within the acceptable standard. This will be discussed in Chapter 7 and 8.

1.5.1 Fire Services Department (BOMBA)(12)

The objectives of the Fire Services in Malaysia are to provide an effective service in fire prevention and fire fighting with the aim of protecting lives and property. They are using the Fire Services Act 1988 as guidelines for their roles, functions and authority within the community. The Fire Services Department also provides guidelines for the public regarding fire prevention and security in all premises. Even though, the fire services department is not considered as one entity with the educational establishment but its existence is playing a major role in combating the fire problems within their specified area of coverage of the community. The building owner and local authority should have an early discussion with the Fire Services Department to ensure that fire safety requirements are incorporated into the initial building design. Therefore, it is logical and practical that all the building plans are submitted to the Fire Services Department for their approval before commencing any building work by the contractors.

Once the building is completed, a follow up building inspection will be done by the fire brigade officers to familiarise themselves with the safety features. If the building is already exists then, a risk inspection for the purpose of obtaining information for fire fighting will be done by the fire officers through several visits. This shows that the fire brigade requirements within the educational building and compound will have to be accommodated. For example, movement space for fire engines around the buildings and accessibility to the boundary and many more aspects must be taken as part of this study. The contribution from the Fire Services may not be emphasised only in the protection of lives and properties from
destruction of fire but also to provide appropriate fire prevention advice and guidance to property owners and effective training against danger of fire.

In the Sixth Malaysian Plan in the Social Development Programmes, 1986 until 1995, the allocation for building more fire station and upgrading the Fire Services Fire Fighting equipment has increased from M$ 38 million to M$ 193 million(13). So, by knowing the functions of the fire services department, the educational administrators should take this opportunity to increase the value of assistance on fire safety from the Fire Services Department by improving their relationship and this will help to increase the standard of fire safety within the educational establishment. The Fire Services Department in Malaysia do have some regulation set for the educational buildings. It is only a guideline and the requirement for the educational building is for approval to be obtained for a building which is still under construction. The guidelines was prepared based on the Uniform Building by-law 1985 and Bomba Act 1988. (Refer to Appendix 1.0). The content of the guidance is divided into 3 parts:-

a/ Part 1: Plans : Submission Requirements
b/ Part 2: (Bomba)Fire Services Department Requirements
c/ Part 3: General Requirements.

The Fire Services Department is also interested in the current research areas below to upgrade their knowledge within this sphere:-

a. Fire Hazard Analysis
b. Fire Growth Phenomena
c. Fabric and Furnishing Flammability
d. Fire Detection and Suppression
e. Structural Fire Protection
f. Smoke Management
g. Legal and Regulatory Aspect of Fire Safety

1.5.2 Insurance and Local Authority

In dealing with buildings, the insurance company and local authority are also very important to consider as they are both involved in economic and other decision
regarding the performance of the buildings. It was stated in the Government Green Paper titled "Future Fire Policy": A Consultative Document (14) on insurance documents says "in so far as insurance offers the means of reducing the impact of fires by providing a financial cushion, the insurance market offers a potential for distorting fire protection decisions by divorcing firms from the full economic implications of their own action or inaction". This means that the pricing policy should be used to give a positive influence on the introduction of fire prevention and fire protection measures. It also states that there is a need for significantly more encouragement of good fire safety management and physical fire protection measures other than sprinklers in certain types of establishments in which sprinkler installations are not appropriate(14).

This shows that there is a need for a proper evaluation procedure on fire safety for buildings so as to enable the insurance company to set a proper rate for fire insurance. The evaluation checklist introduced in Chapters 7 and 8 may assist in making "Trade -Off" decisions about the fire safety components installed within a building to create a level of acceptable risk where the building owner would benefit from the introduction of cost-effective fire risk management techniques.

The state and local regulations are generally more specific to fire safety in the form of building codes or standards and fire prevention requirement. As for the Malaysian local authority, the fire safety provision is being stated in the Uniform Building by-laws 1984 which consist of all the general requirements for building construction and also fire safety in buildings. Since, approval must also be obtained from the local authority and for these reasons, one should look thoroughly in that document and if possible to analyse it, so that a better understanding about the subject is uncovered. In Chapter 3, the document analysis will cover mostly all the fire safety requirements stated within the Uniform Building by-laws 1984 (15) which relates to buildings in general and specifically to the educational establishment.
Fire safety research work has been going on for many decades and now it is being recognised as a new extension of science and a part of the engineering disciplines. A lot of research being carried out particularly whenever there has been a major fire accident(s). All kind of achievement and the use of the research findings in terms of fire safety studies has been acknowledged. Yet work is still being carried out continuously by individual researchers and major organisation to cater the need for improved fire safety engineering applications in the construction arena.

The past fire disasters within the educational establishment has brought the intention to evaluate the fire safety requirements of current buildings and projects under development. These studies are trying to evaluate that fire safety problems that do exist within the boundary of the educational establishment. The new fire safety evaluation procedure introduced for educational establishment could be useful. The main objectives of the fire safety evaluation studies on the educational establishment in Malaysia will be focused on the following:-

i/ Life Safety
ii/ Property Protection
iii/ Education Continuity
iv/ Education Environment
v/ Public Anxiety
vi/ Economics

The target group are the full boarding secondary schools and universities which are directly or indirectly run by the Ministry of Education. The reasons for choosing the particular group are based on the fact that the secondary and university students for their capabilities in terms of making decision and act towards their environment more independently. This will also ensure that the scope covered would not be beyond the resources available.

Most of the occupants of the buildings will be involved in answering a questionnaire, and perhaps the collection of data on human behaviour and level of awareness which are supported by the risk and safety factors within the educational
establishment. Based on the literature review and primary data gathered, the problems faced by the educational establishment in terms of fire safety requirements can be inquired into through 4 separate stages:-

a) Stage 1: Questionnaire (Chapter 4)
b) Stage 2: Professional Judgment (Chapter 5)
c) Stage 3: Experimental Work (Chapter 9)
d) Stage 4: Evaluation Procedure (Chapter 6, 7 & 8)

However, the initial approach that has been taken before pursuing the above stages was analysing the Uniform Building By-laws 1984 which related to the laws of Malaysia particularly for building construction requirements. The purpose was to look at the fire safety requirements that are written within the laws and the use of British Standards and Codes of Practice including other standards as the references to form the whole regulation within the book (Uniform Building by-laws 1984). Furthermore, the fire requirements for each area or building can be evaluated by referring to the text of the laws which is used to form the check lists to give a certain points for the purpose of a qualitative appraisal of fire safety in the educational establishment.

1.6.1 Stage1: Questionnaire- Survey search.

This was conducted to gain information for the quantitative and qualitative data appraisal. Among the important aspect of conducting such survey is to know or to establish a general reference on occupant awareness towards fire safety within the educational establishment. This includes such as: background of the occupants, training conducted, knowledge on fire fighting and extinguishing, escape routes and procedures, rules and regulations within the premises and management considerations. Besides, the specific areas of interest, information on fire safety equipment available and risk assessment was also obtained. This information will ease the implementation of the procedures according to the existing and future requirement of fire safety in educational establishment. Based not only on professional judgement but also from the occupants' points of view or considerations.
1.6.2 Stage 2: Professional Judgement

The study of loss impact, importance and qualitative appraisal plus the formation of the organisational body in getting the fire safety requirement and perspective into action can be achieved via professional judgement. A Delphi group was formed by the involvement of professionals from different expertise and knowledge background based on their interests. The selected members were representing the Malaysian population (in theory) in terms of their perspectives and knowledge or judgement on fire safety condition and requirements in secondary schools or the educational establishment as a whole. A set of questions and answers were given for the members to choose and discussed. The whole process was conducted through several meetings organised by the researcher. Among the findings was the loss impact caused by different buildings within a certain community. But the most important is the effects of school fires on the community around it and also the loss impact to the local, national and international community. A quick reference and advice can be given by the Delphi checklist to be used by professionals and administrators in dealing with fire in buildings particularly in the schools. The policy, objectives, tactics, components and sub-components of fire safety have been established to cater the need of fire safety within the educational establishment. The outcome then can be used to produce the checklist and procedure for the fire safety evaluation of the educational establishment in Malaysia. These procedures will have to be tested with local schools in Malaysia or in the UK for the effectiveness of the whole operation.

1.6.3 Stage 3: The Experimental Approach Investigate The Optimal Location for Smoke Detectors.

The experiment is to find out the level of smoke detector performances caused by the degree of inclination or slope of the roof or ceiling, the sizes of space and height of the areas. It is a physical model based on standard building plan of a Malaysian School designed in a modular system for easy expansion or change in the use or function of an area. However, different roof angles were tested and with the flexibility of the physical model it is hoped to prove that changing the slope of the roof will give a range of detector response times. Such results may suggest new
procedures to the design of the layout for smoke detection systems in buildings. This type of information will help to convince the public of the importance of having smoke detectors in a building areas. The experiment is based on the heat produced by a rubbish bin fire (to a scale 1:20) and using K-type thermocouples as the smoke detectors possible location which are based on the temperature difference within 5 minutes exposures.

1.6.4 Stage 4: Fire Safety Evaluation Procedure (Check Lists)

A point scheme method to evaluate the Educational Establishment will also be introduced. The study is related to the evaluation of fire safety schemes used in Hospital Patient Areas (Scotland)(16), Dwelling Houses(17) and the Industrial Buildings (Probe)(18). The concept is now focused on the fully residential secondary school in Malaysia. The approach is to establish the method to measures fire safety standard in existing and future schools using a points scheme and also the checklist that have been developed. The buildings should at least be in the acceptable safety standard based on the evaluation process where building regulations, occupancy and building condition has been considered. The authority can proceed to either improve or maintain the existing condition of fire safety for a particular school or any other similar educational buildings. The outcome of the evaluation then could be used to assess the level of acceptability in terms of fire safety and the results should be good enough to convince the decision makers on making the building to the level of safety required.
References:


3. Malaysian Fire Brigade Force (BOMBA), Kuala Lumpur, 1993


17. Shields, T.J., Silcock, G.W., and Bell, Y., "Fire Safety Evaluation of Dwellings", Department of Building, University of Ulster at Jordantown, Northern Ireland (UK), Revised in June 1985.

2.0 Introduction

The Government of Malaysia has promulgated that the main purpose of education and training is to provide every individual or citizen with appropriate knowledge and skills. The educational curriculum is mainly set to produce a balanced and responsible individual not only based on the relevant knowledge and skills but also with strong moral and ethical values. The Malaysian Education establishment also is trying to develop a technically competent labour force and to enhance the competitiveness of the Malaysian Economy. Among other major objectives will be as follows:

1. To eradicate poverty.
2. The restructuring of the society.
3. To increase income and employment opportunities.

Education is one of the most important aspects for future development of the nation. In Malaysia, the development of the educational systems can be divided into 3 stages:

a). Pre War (before 1940)
b). Post War (after 1957 to 1970)
c). Current (after 1971)

However, a survey done by the Royal Safety Commission of Malaysian Schools(1) has shown a great increase in the percentages of school buildings being constructed until 1990.

<table>
<thead>
<tr>
<th>School buildings 1961-1990</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before War</td>
<td>12.6</td>
</tr>
<tr>
<td>After War 1961 - 1970</td>
<td>23.8</td>
</tr>
<tr>
<td>Built During 1981 - 1985</td>
<td>23.1</td>
</tr>
<tr>
<td>New Building 1986 - 1990</td>
<td>52.5</td>
</tr>
</tbody>
</table>


It was stated in the Education Programme for Sixth Malaysian Plan(2), that work has been done to cater for the increasing demand for education during the year

2.1 National Education Policy

The Minister of Education, Encik Anwar (10) said that, education had always been one of the government's priorities and they had never imposed any restrictions on the pursuit of education. Although Bahasa Malaysia has been adopted as the National Language the government still allow the other communities to set up Chinese and Tamil speaking schools.

Education is still a principal priority of the government and millions of dollars have been allocated each year to ensure that the public has got the proper and adequate education. Schools have always been a part of the big issues in politics. The steps to build more hostel accommodation for the students by the Ministry of Education seems to be very critical to overall progress. Hostels have been a major topic in most of the educational discussion. This shows that boarding school building is in a highly demand and very important part of the total educational development. Its' main purpose is to provide a good place to educate the young pupils with a proper knowledge within the right environment.

The National Educational Policy as a whole can be explained in two parts (A) and (B):-

Part A) The National Educational Goals which are aimed(3) :

I. To Achieve National Unity.
II. To Produce Quality Manpower Requirements For National Development.
III. To Achieve Democratisation of Education.
IV. To Inculcate Positive Values.

It has been long that the objective of the Ministry of Education to see that all the public; regardless of their background, beliefs and well being to have an
adequate education to ensure that educational democracy in Malaysia can be achieved. Among the objectives to be achieved are:-

i. Increase the level of knowledge to the stage that the new generation will be able to cater all the possibilities that the future might need.

ii. Excellence not only in academic but also in moral issues and mental attitudes.

iii. To establish a sense of community.

Part B) The National Educational Philosophy

It is quoted by the Ministry of Education(3) that,:

"Education in Malaysia is an on-going effort towards the further development of the potential of individuals in a holistic and integrated manner, so as to produce individuals who are intellectually, spiritually, emotionally and physically balanced and harmonious, based on a firm belief in and devotion to GOD. Such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards, and who are responsible and capable of achieving high level of personal well-being as well as being able to contribute to the harmony and betterment of the family, the society and the nation at large."

It seems that the safety of the educational buildings are amongst the main contributions towards realization of the National Education Policy. All started from a safe place or building with provision of security, better environment for education continuity plus a good services that can lead us to the achievement of the National Education Goals. The Government have to ensure that every individual is safe and given all their basic education needs and even comfort to educate them successfully. An assessment of the education curriculum is also important to be considered but the facilities and buildings also should be protected and prevented from any danger or risk particularly fire and well equipped with the provision required. Since the requirement of fire safety for students must be fulfilled to a level of satisfaction and to a specific comfort, there are many things that the Government needs to consider such as the future expectation in educational system, development of the educational buildings, the
facilities, comfort and the acceptability level of safety standards must be established.

Basically, the students should be guided to take the opportunity to explore the available facilities and knowledge within the system and to create the awareness of many things, including fire safety, which will able them to develop themselves a positive attitudes and ready to face the possible danger or task to the level of the National Educational Philosophy expectation.

2.2 Education: Organisational Structure of the MOE, Malaysia.

Malaysia has a centralised system of educational administration. Its administrative structure is organised at four hierarchical levels, namely the national, state, district/division/residency and school. One should know the level of decision making within the organisation of interest because then only the relevant issues can be dealt properly and systematic.

a. Ministry of Education (MOE)
b. State Education Department (SED)
c. District Education Office
d. School

The National Education Policy is being made by the top level within the organisational structure of the Ministry of Education (MOE), Malaysia. In some countries, the area of research will need to get some kind of approval before one can proceed, in this case the Ministry of Education for Malaysia. The approval letter from the ministry is important to assist in getting the cooperation of the respondents in dealing with the questionnaire or survey research especially if the research is carried out by an individual. Besides, the findings of the research can be disseminated directly to the bodies within the establishment that are concerned about particular problems.
2.2.1 Ministry of Education (MOE)

It has been stated(21) that the

"decision-making at the MOE is performed through a system of committees. These committees are established to facilitate inter-division and intra-division decision making. The Educational Planning Committee (EPC), which is chaired by the Minister, is the highest decision-making body at the federal level. It is concerned with educational policy adoption, adjustment and implementation. The secretariat to this committee is the Educational Planning and Research Division (EPRD). Certain policy matters in education that have wider ramifications are referred to the Cabinet, before final decisions are made".

However, on the 9th May 1994 the Malaysian Educational Research Council(MERC) has been set up under the EPRD in the field of educational research and evaluation at the national and international level. The MERC is formed to ensure that an awareness on the importance of educational research and evaluation and the application of the findings to policy-making, teaching and learning practices and on the country's educational development can be increased and maintained. Refer to Appendix 2.0 for more information on the MERC(4).

There has been no proper research focused on the physical needs of the educational buildings particularly the schools specifically in terms of fire safety. With this in mind, the fire safety evaluation procedure that is being introduced in this research study has found the right channel in the Ministry of Education of Malaysia to propose and to implement the findings. The board of MERC is the initial decision makers that will evaluate the fire safety evaluation procedure before it is being brought up to the knowledge of the Education Minister for the implementation purposes. The implementation of the Fire Safety Policy for Educational Establishment can be channeled through the MERC to see the effectiveness of the evaluation procedure.

2.2.2 State Education Department (SED)

The educational policies and plans made at the federal level are being implemented and carried out at the state level through the fourteen State
Education Departments. The SEDs will ensure the implementation of the education policies, supervised and monitored the national education programmes, projects and activities as well as giving feedback to the central agencies for general planning.

2.2.3 District Education Office

The District Education Offices are acting as intermediate linkage between schools and the SED. The function is to support the state level administration system.

2.2.4 School

The Headmasters or principals are being assisted by two or three Senior Assistants in handling the administrative leadership and providing professional standards in schools. Almost every school has a Parent-Teacher Associations (PTA). This is required by law and that it is necessary to foster cooperation between the school and the community.

2.3 Category of Education in Malaysia

Educational matters are something that are very well known to almost every individual. This is the result of the schooling system which was introduced in order to educate every individual to become an elite who will know how to write, read, count and reason. Even, the Government intentions are to produce a well educated generation who will be able to contribute to the human resources in fields of all kinds. In general there are several types and levels of educational buildings. They were built to suit every individual need in the search of knowledge. Everyone will have to pass through several stages of examination levels to evaluate their achievement in education. The structure of the Education System in Malaysia is given in the Chart 1 (5). (refer to Appendix 2.1). The normal procedure is to go through the following stages of levels:-
1. Lower Education
2. Higher Education

2.3.1 Lower Education

This level of education can be divided into several other stages:-

i. Pre-School or kindergarten (nursery)
ii. Primary School
iii. Secondary School which is divided into 2 categories:
    a) Lower Form and
    b) Upper Form

2.3.1.1 Pre-School

Government role in the pre-school education was to prepare the curriculum and dealt with registration. The aims of this pre-school education is to provide a base for the child to prepare for the primary school and generally being sponsored by both public and private sectors. In 1990, 77% out of 6,960 pre-school centres were run by Government agencies and statutory bodies (2).

<table>
<thead>
<tr>
<th>Year</th>
<th>1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Pre-school centre = 6,960</td>
<td></td>
</tr>
<tr>
<td>Government</td>
<td>5,360 (77.0%)</td>
</tr>
<tr>
<td>Private</td>
<td>1,600 (23.0%)</td>
</tr>
</tbody>
</table>

(pg.: 158, Sixth Malaysian Plan 1991-1995)

2.3.1.2 Primary School

Primary education is divided into two category:

a. Government school
b. Government Aided school.
The involvement at primary school level had reached 99% of the relevant school-going population during the period of 1986 to 1990 and still showing an increasing rate. The average class size was as high as 44 children per class (6). The number of pupils enrolled each year is getting higher and this shows that there is a high demand for more classrooms or school buildings in the near future. (More information on students enrolment in local Public Institutions can be obtained in page 160: 6th Malaysian Plan (6)). The basic skills thought using the new curriculum KBSR is focusing at the ability to read, write and doing arithmetic.

<table>
<thead>
<tr>
<th>Years</th>
<th>Primary Education Total Enrolment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td>2.19 million</td>
</tr>
<tr>
<td>1990</td>
<td>2.45 million</td>
</tr>
</tbody>
</table>

(rg.: 158, Sixth Malaysian Plan 1991-1995)

There was an increase by 11.7 % in the total enrolment of the primary school during the period.

2.3.1.3 Secondary School

The secondary school will develop along with the increment of students continuing their education from the primary schools. It was found statistically (7) that the transition rate between the primary and lower secondary levels in Government and Government aided schools had remained constant at 84% during 1986 to 1990. This may have resulted from the enrolment of students in other private schools or the Islamic religious secondary schools managed by state government or by private individual or organisations.

However, the increment of enrolment registration percentages for the secondary school from the primary pupil can be shown as 40.7% in 1986, 40.9% in 1987, 46.6% in 1988, 48.3% in 1989 and 51.0% in 1990. The statistics given on students enrolment for secondary schooling from 1985 until 1990, based on the survey done by the Ministry of Education (8).
The curriculum introduced at the secondary level is called KBSM which giving greater emphasis to business-related and pre-vocational subjects. A new subject called "Living Skills" was also introduced which is incorporated with business knowledge, technology, commerce and entrepreneurship. However, science and arts subjects are still the major subjects thought at this level. An increasing number of fully residential science schools were built and effort to equip science laboratories has been considered to cater the needs of the increasing number of students in the science stream.

2.3.2 Higher Education

This type of education is divided into several stages as well:-

i. Undergraduate (seeking for certificate/diploma and degree).

ii Post-graduate (consists of individual with degree/diploma or doctoral degree etc.).

There were substantial increases in enrolment in the higher education which were made possible with the expansion of existing institutions and the completion of new ones. Mostly the higher education is catered by polytechnics, technology institutions, training colleges and universities.

Generally, educational establishment will also involve building types such as offices, laboratories, workshops, lecture halls or classrooms, sleeping accommodations, canteens including building services and others measures. The provisions within the establishment are not only to cater the needs of the normal occupants but also undertaken to increase the educational facilities for handicapped children.

Among the objectives of the Malaysian Education are(9):

1. To ensure that quality education and training is accessible to all Malaysians
2. To mould individual the right attitude towards life and work
3. To equip them with knowledge and skills, necessary to make Malaysia a developed nation by year 2020.

4. And to achieve national unity and integration.

Education is something that will never end as long as there is something to learn or knowing about in our life. The demand for education will be greater as the population and country needs to develop. The fire problems within these establishments have to be controlled and kept to the minimum possible as a fire could have a major impact and present an unacceptable loss.

There are also efforts for future development concerning handicapped mobility facility in buildings by the Malaysian Government. The Government is looking forward to improve the school or education buildings to enable them to cater for the predict future needs. (Refer to Appendix 2:1: Education Structure and School System)

2.4 Types of Secondary School (depending on the sponsorship)

There are many types of secondary school exist within Malaysia. However, generally the schools can be divided into several types:-

c. Semi Government (Partly private)
d. Private Residential School (Fully or Mixed)

Most of the school is operating based on the source of income or support given by the government or private organisation. The categories of sponsorship to run the school in Malaysia can be classified into 3 major group:-

a. World Bank
b. Government
c. Public or Private (i.e.: based on Ethnic/ Religion/ Social Status.)

These resulting different level of standards in terms of buildings, facilities and provision, perhaps it might have the effects on the pupils achievements, broaden
up the social status among the community and creating unhealthy mixture of influence particularly involving the politics. The urgent needs in standardisation of the school's management and supervision will have to be done at some point by the Ministry of Education. This probably helps in maintaining the schools function in a positive ways for the country to develop in the future. Therefore one of the major step is to set an evaluation procedure for fire safety assessment for the schools as the starting point.

2.5 The Functions of School

There are several things that school can always do in contributing towards a community development. Eventhough it's main objectives are to provide and convey knowledge to the people, the development functions that can be run within the schools are as follows:-

1. Individual mental development (learning faculty)
2. Individual physical development (sports activities)
3. Moral development (religion/ discipline / responsibilities)
4. Community integration (ethnic/ cultural/ parents and teachers society)
5. Community public gathering
6. Cultural exchange and understanding.
7. Community centre or base for natural disaster
8. Nation future development in all other aspects.

(Note: Probably very useful for Delphi Group Discussion Part A-->E)

Based on the Malaysian Education Policy which is to produce students and citizens with knowledge, good personal conduct, courtesy, responsible and able to gain personal satisfaction and happiness to live in harmony and peace within society and country; and conducted within the school, cultural activity which involved leadership, working capability, communication and interaction, classroom, learning and teaching are all the function of a school.
It was stated by the Ministry of Education (11) that in a house of 4.5 person, any housing estate consisting of 1250 unit houses must provide at least one primary school and perhaps one secondary school if more than 2500 unit houses is to be built within the housing scheme or estate. Educational establishment also acting as the centre of community. The participation of the community with the development of the schools, particularly the parents of the pupils has been tackled through the PTA (Parents-Teachers Association) arrangement. Some of the activities taking place within the school are open to the public to bring together the two group closer as parts of the National Education Goal system. The activities are such as; The Annual Prize Giving, The Annual Sports Events, Exhibition on Pupils Performance or Educational Aid and Advancement in Educational Facilities, Traditional Cultural Shows, Open Days, Religious Activities, Foster Families and a lot of others. By doing this, the public will have a clear perception towards the development and the safety of the schools and the pupils, also building up their confidence of the administration of the school and the Government. Amongst the future demands are such as:-

a. New school building design.

b. Higher level of safety.

c. Attractive environment

d. Higher comfort level required.

School future development can be improved by several aspect that need to be considered:-

a. Teachers should help by creating a positive and healthy school culture.

b. Creating positive school image and classroom environment.

c. Good and healthy interaction and communication.

d. Involvement of the community and parents.

e. Improve students’ potentials in everything.

f. Provide positive ways of living.

g. Produce a responsible and honourable student.
2.7 Residential or Fully Boarding Schools

Basically the boarding school has been a major topic in most of the educational discussion. The public is also showing high interest in sending their children to a fully residential secondary school or boarding school. Its main purpose is to provide a good place to educate the young pupils with a proper knowledge within the right environment. Among the reasons for the parents to choose the boarding schools than an ordinary school is because the full board school is normally provided with:-

a. All sort of equipment
b. Language center
c. Library
d. Computer Center
e. Equipment for sports and co-curriculum activities
f. Hostel buildings
g. More systematic learning based on time management
h. Students will have no problems with transportation, daily climate and friends,
i. The teachers are having higher commitment level to improve the education standard for all their students.

The boarding schools also get the priority attention and interest by Ministry of Education in providing more facilities than ordinary schools. Besides, the school pupils were selected for their excellent academic achievement in the primary school. Other reasons are that the teachers are well trained and are provided with sophisticated teaching aids. However, Mr. Anwar Ibrahim(10) said that the purpose of setting up the boarding schools are not only for those who excel in their academic studies but also to give chances or provide for the pupils of poor families from rural areas and squatter's homes a better study environment with hostel which is close to the school or colleges and able to expose them with the new style of education within the urban area.

The above can be summarized that the boarding school has always been the choice for most parents to send their children because the provision of the education facilities is better, students will be well disciplined with proper time
management and having a trained teachers. There is a tendency that a lot of people especially parents who wish to send their children to residential or boarding schools which are being subsidised by the government or other organisation. The percentages of student recruitment for boarding school were reported to be as follows(11):

a. 70% for student from rural areas.

b. 30% for student from urban areas.

Both categories (a) and (b) are being selected on the basis of their socio-economy capability. With all the demand for boarding schools and also the history of fire accidents within the educational establishment, shows that the Ministry of Education has to undergo a serious study in providing the educational accommodation places which are free from fire ignition. A total fire free place is not possible to provide as the different functions of a building will have to include other aspects of building performances in order to run the activities set for each area within the building. We can define education into so many other field in life but in order to narrow down the scope of study, the researcher confined the studies on education only towards the buildings in the Fully Residential Secondary School.

2.7.1 Types of Residential Secondary School in Malaysia

There are two major categories of school:-

1. Government School which is fully sponsored by the government.
2. Government Sponsored School which is only depending on the capital such as paying salary to teachers but not the land and buildings.

Types of boarding school sponsored by Government:-

1. Technical Secondary School (semi-boarding)
2. Vocational Secondary School (semi-boarding)
4. Mara Secondary School (full-board)
5. Regular Daily Secondary School (semi and full board)
7. State Religious Secondary School (semi and Full board)

Most of these schools are built based on the standard building plan which is provided by the Ministry of Public Works. Majority of the areas or zone for the educational buildings can be divided into:

a. Academic - classroom, laboratories, workshops
b. Administration - offices, meeting room
c. Students hostel or sleeping accommodation
d. Sports Complexes and gymnasium
e. Staffs accommodation.
f. Infra-structure.
g. Public buildings such as canteen, prayer hall, assembly hall.

2.8 Problem Identification

The problems facing by the educational establishment particularly the secondary schools has been widely noticed by the Ministry of Education, media and also the public. However, the source of information on the problems within schools can be obtained from the primary and secondary data as follows:

a) Government Report(Yellow Report),
b) Previous research on educational establishment
c) Newspaper
d) Visits to Schools and Universities(Walkthrough Assessment)

2.8.1 Government Report

It has been reported that the survey research done by the Royal Safety Commission for Schools in Malaysia 1989-1990 (15), found out several problems at school related to fire safety particularly and safety as a whole. Among the problems stated within the schools are:
i. Lack of emergency lighting, portable extinguishers, emergency staircases, and fire fighting equipment's. These need to be improved and reduced the percentages of schools fall into these categories.

ii. Effort needs to be given more in providing training and courses and opportunities on fire safety amongst the staffs because there are high percentages of staff do not know how to use the fire safety equipment available. It was only 46.4% out of 330 schools involved in the study know how to deal with those equipment.

iii. The major sources of ignition are the electrical equipment's which are used in most learning and teaching purposes, including gaseous and chemical substances. Most of them are used in the laboratories and these form as the highest priority of area which is vulnerable(16). This has been confirmed by the questionnaire undertaken in Chapter 4.

iv. There are lack of fire drills or fire emergency training courses for the students at school. About 79.5% of the students(out of 330 schools) did not participate in any fire drills during the period of a year (1989 to 1990)(17).

v. There is lack of interest in most of the school management who were visited during the survey to organise fire safety talks, fire safety awareness week and techniques in fire fighting demonstrated by the fire brigade officers(17).

vi. Inadequacy of the emergency mode such as the alarms, exit doors, fire fighting equipment's and also internal layout for the hostel building.

vii. Lack of signage and information on fire safety within the hostel buildings particularly involving the critical areas such as laboratory, canteen, kitchen, dormitory and home science rooms.

viii. Overcrowded dormitories and classes, need a bigger room for better comfort and environment.
The analysis of the document did suggest that there is a need for a guidelines involving school and hostel construction planning to refer for the requirements of the standards (18).

The safety commission also found out that there are some problems in terms of the maintenance work of the fire safety equipment which are not done properly, the choice of system installed is not correct, changes of the areas function for different purposes without looking into the needs of changing or improving the building materials and quality, lack of hydrant within the schools compound and water supply, no procedure to use the available fire safety system where most of the system is to be handled manually, electrical cable that need to be changed over time, low quality electrical switches and appliances are being used, not being consented by the authority for any alteration or renovation of building works of the schools and hostels.

These are the reasons why standard plans for school and hostel is being produced by the Department of Public Works (JKR) to be referred in any newly built schools or hostels. But what about the fire safety requirements? Is there any procedure to follow or is it adequate to accept the current fire safety standard?

Other proposed consideration that need attention and was suggested in the report are (19):

- Fire resistance materials in building design and improved safety and comfort levels for education purposes by introducing a standard design requirements.
- Materials use for interior decoration or finishes should be tested.
- Any burning fuel should be excluded from an open area. (protected in an enclosed compartment)
- Should provide more sophisticated fire safety system besides fire alarm and financial support from the government.
- Provide a better facilities for rubbish disposal.
- A systematic approach on maintenance and management need to apply in order to ensure having a higher level of fire safety standard.
g. Increase the level of fire safety awareness (the danger of fire and aspects of fire safety) among all the educational establishment occupancies.

2.8.2 Previous Educational Establishment Research Data

There have been few other research considering the secondary school prestige as of performance in Malaysia. In 1989, it was reported(14) that the purpose of evaluating the school prestige as an performance achievement is to ensure that the National Education Philosophy can be achieved involving the pupils intellectual, emotional, spiritual and physical development. And not only that, it also considered other aspects such as the academic achievement, co-curricular activities, discipline of the pupils and the effectiveness of the school management, learning and teaching environment, facilities and also the cooperativeness of the staffs. In the same research(14), the best secondary schools performance are being evaluated according to the following:-

1. Effectiveness and firmness of the school principals.
2. High academic achievement.
3. High morale and behaviour of the students and the teachers.
4. Occupancy motivation.
5. The building and services maintenance
6. Good relationship amongst all the occupancy.
7. Good and adequate physical facilities in house.

It shows that the research do emphasised on the effort of making the school complete and adequate with all the physical requirements providing for education purposes and improve any deficiency if any. So, the fire safety requirements is one of all the requirements that must be catered in order to maintain the continuation of the educational mission. The above suggested performance evaluation can also be used to assist in the fire management task.
In another case study done on the use of information in the educational planning process in Malaysia 1989, shows that there are 2 major level of decision making(20):

- a) Macro level (involving the Ministry of Education Department)
- b) Micro level (more towards State and Local Education Department).

This decision making process is done through a board of committee system. It shows that anything that need to be introduced into the educational system must go through these two levels before it is taken for implementation.

In the UK it is confirmed that schools are the main target for serious arson fires reported in 1994(12) which cost nearly 14 million pounds sterling. Solutions is to provide an accommodation for school teachers when designing school buildings. This practice(13) has been implemented by most residential schools in Malaysia with the benefit of:-

- a/ Having permanent staff on site.
- b/ First aid fire prevention.
- c/ Reduce the problems of shortage of housing for teachers.
- d/ Encourage better school maintenance.
- e/ Assist with crime prevention.

So, among the major problems in making the National Education Philosophy a realistic achievement in terms of safety and comfort is the danger of fire in schools.

2.8.3 Local Newspapers

The problem identification through the mass media particularly newspapers will not only cover the problems but also some suggestions given to solve the matters. It will be arranged in several headings or topics of interest.
a). Building Requirements

It was reported by the Ministry of Education (MoE) that schools has to be designed using a standard plan for schools which the structure and foundation of the buildings and fire safety precautions should have professional approval. Future schools and hostels are built according to modular system which it can be added to if needed (22).

The areas within schools include: Classroom/ administration office/ teacher's room/ multi purpose hall/ mosque/ canteen/ playing field/ open space for car park or bicycles/ libraries/ resource centre/ hostels/ prayer room/ store/ reading room/ computer room/ science laboratory/ special classroom/ audio visual room/ music room.

Furnitures: includes such as beds, cupboards and lockers, notice boards, chairs, desks for hostels and administration offices.

A board of inspectorate in each state is required to inspect and ensure that appropriate building maintenance were carried out. There are needs for more classrooms, schools and hostels. Therefore, the requirements fire safety also is in need to overcome any fire emergency and could be used as a guideline in design.

Among the school building design factors to be considered are:-
1. Design.
2. Level of safety.
3. Attractive environment.
4. Comfort level required.

The suggestions to overcome the building design problems (23):
1. Having standard school plan can assist in minimising the construction time to meet the demand.
2. Cement roof tiles can be used to replace the asbestos sheet roofing.
3. The present designs for schools are more than 10 years old and a new flexible and bigger design is needed.
There is a need for a comfortable, safe and attractive atmosphere at school. "The school design is out dated", said by the Tan Sri Haji Mohamed Khalil Yaakob (24). He also pointed that the "Present designs were drafted before war". Of course not all designs but the pre war buildings still exist and then may cause problems in the near future. So the MoE should improve the design of school to accommodate the future needs. It was recommended that:-

1. 20 hectare of land area is required for the building of one residential school
2. Emphasis is to improve the physical structure of schools and ensuring that they are built in reasonably attractive surroundings.

b). Design Requirement:

1. Hostel should have hose reel/ fire extinguisher and areas that do not having a piped water supply should have a standby water pump.
2. Alternative for not providing the fire fighting system are having more doors and wider corridors for escape purposes.
3. Minimum distance between two building is 5 metres (15 feet) apart but for 2-storey building will require at least 7 metres (20 feet) apart.
4. Area size to accommodate 87 pupils in 2 storey building is 4000 sq. feet.
5. Ensure that the water pressure is enough.
6. Need to reduce the time for approval.
7. Hostel staircases should not be less than 2 metres wide.

The main purpose of designing and building school hostels are as follows (10):
1. For poor families.(rural areas and squatters homes)
2. For better study environment(close to school or colleges)
3. To expose the rural students to new style of education in the urban area.

The Royal Commission of Inquiry on Schools Safety 1990, also suggested that more building up of a school complexes including areas for academics and accommodation are needed (25). There is a tendency to build a multi purpose building or a complex building to house several function in the school buildings.
such as the building built by the Kong Min Chinese Primary School having within
the double storey building, assembly cum badminton hall on the top floor and
canteen on the ground floor (26). However, in some cases, if there is a fire
emergency coming from the canteen will result that the assembly hall is useless
and the cooking smell might interrupt the concentration of pupils during the
assembly. Of course, a possible solution will have to be considered about the
best way to be able to use that assembly area to the best it can offer and the
management might say that in case of fire emergency, the building occupants will
be assembled at the open areas outside the building in which the Malaysian
climate may change and cause other problems such as heavy rain and lightning.

The Royal Commission of Inquiry on School Safety also has set up the criteria for
the research into the following(27):-

1. Building- external design plan
2. Fire Safety Equipment - maintenance
3. Health -public health
4. Comfortability -spaces external and landscape
5. Electrical wiring

c). Building law

The Asean Paediatric Federation; legislation pertaining school buildings must be
made. The steps (28):-

1. Set up a safety council for schools. Members should includes;
educationists, medical doctors, architects, parents, fire fighters,
environmentalists and lawyers.
2. Should have it's own health and education inspectors to check on safety.
3. Organising safety campaign to emphasis on awareness and prevention.

d). Economic

The allocation of budget from the government on educational buildings are
going higher and higher (29).
- RM$577 million (£115.4 million) to build primary school each RM$1.2 million (£0.25 million) comprise of 8,070 classrooms having minimum of 18 classroom each.
- RM$540 million (£108 million) to replace and repair RM$280 million (£56 million) classrooms for secondary schools by 1993.
- RM$140 million (£28 million) sport schools each RM$20 million (£4 million) (seven schools).
- RM$403 million (£80.6 million) for 12 vocational schools in Sixth Malaysian Plan.
- RM$15 million (£3 million) for renovation and buy equipment for 46 vocational schools.

Economic: It is important for the local authority to consider that the schools need improvement in terms of:-
1. Materials for construction
2. Facilities
3. Productivity
4. Distribution of allocation.

Economy can contribute towards the achievement of the National Educational Objectives with good management and be able to provide the safety requirement for school not only in terms of system installation but occupants' awareness is considered to be vital factors to ensure the safety performance is maintained and achieved better.

Shamsudin S.(30) has suggested 2 ways to improve the schools condition are:
a. Concepts one for all and all for one. (kekitaan)
b. Love the school. (semangat cinta kan sekolah)

She said that the State Education Dept. has also conducted fire drills, taught on how to fight fire, the use of the fire extinguishers and equipments, including held classes on fire safety. The two major things being emphasized are the: 1). Fire escape 2). Fire fighting equipment. As the consequences of these, she believed that the pupils are more disciplined and everyone is taking care of the school. Arsonism and malicious fire raising may also be controlled.
e). Problems At Schools (Other than Government School)

The general safety and condition of religious schools, the hostels and private institutions were unsatisfactory. Amongst the problems are (31):

i/ Living and studying in a congested buildings
ii/ Lack of safety and public health
iii/ No proper sanitation
iv/ Over crowded and poor fire escape exits
v/ Staircases blocked
vii/ Windows with grill, difficult to escape during emergencies.
viii/ Renovation of the premises without obtaining advice.
ix/ Hostel warden or prefect are not trained nor have knowledge on fire safety. As a result they could not give a proper assistance during emergencies.

Problems: Most Private and religious schools is facing (27):
1. Lack of fire safety equipment or protection
2. No briefing on safety
3. The school located in the remote area
4. Difficult to reach by the fire brigade engine.
5. Building construction from combustible materials.
6. Distance between building are too near or close.
7. Lack of or no escape route and emergency staircases.
8. Maintenance and security of the hostels and schools are not satisfied.
9. School administration did not emphasize the important of fire precaution and planning aspect.
10. Lack or short of budget and allocation for the whole school particularly in this case to provide fire safety equipment or requirement.

Other problems created by private school:
1. No prior approval from the authority.
2. Equipped with fire extinguishers but no fire drills were ever conducted.
3. Frequent power failure and resulted in using candle light to study late night.
4. Financial constraint particularly to allocate for the improvement of the provision and facilities.
5. Distance of the school to the nearest fire brigade or station is too far.
6. The number of Fire Brigade Officers on duty took too long time to respond to the emergency.

f). General problems: Lost to the impact of development.

Some of the schools in town areas should be able to cope with the condition surrounding vice versa and not to be removed. Of course the restriction of land caused the school becoming cramped and not suitable. However, in the first place, the development of building and surrounding should be controlled to suit the existing school building, not the school has to follow the surrounding. The problems are such as:

a) School buildings are close to the road.
b) Its location is between the shopping complexes.
c) Need for a sports complex
d) Lack of space or areas for extra-curricular activities.

g). Needs for safety at school or hostel

1. Trained warden and representative
2. Involvement of the building professional during design and construction of the buildings.

h). Hostels: Fully-Residential School

The reasons why fully-residential schools are special to the public:-

i. Got the priority attention and interest by Ministry of Education in providing more facilities than ordinary schools.
ii. School pupils were selected for their academic achievement in the primary school.
iii. They are provided with sophisticated teaching aid and well trained teachers.

The need of building more residential schools in Malaysia are seems to be essential and has the interest of parents. The semester system also being introduced into the school.
There is a tendency to build more hostels because of the increasing number of students. Overcrowding in the existing hostels are among the problems. Hostels will be built with more comfortable. However, building planning and decision making with the local authority take a longer time which cause delay in order to proceed with the construction of the project (32).

I. School Performance Improvement

The steps to improve the school performance and prestige:-

1. Physical Infra-structure/ tidy and clean/ safe/ comfortable and beautiful school which can attract students to school or give a good learning environment to those students within the school.

2. Teachers' expertise/ cultural organisation/ parents' and society involvement. All will help to create the positive and healthy environment. Then this environment will lead to general decision making/ commitment/ good communication and sincerity plus highly morality.

3. Harmony in the environment can be created by having good understanding between teachers and students and headmaster/ feel free to proceed with their responsibilities/ have a high and respective moral/ open communication/ orientation working procedure/ highly motivated and understanding.

Other considerations (33):-

2. Social aspect
3. Knowledge cultural aspect

The problems faced by the higher educational establishment such as universities and colleges are :-

1. Land constraint
2. Lack of students accommodation
3. Lecture halls or theatres.
4. Changes of area function.
5. Existing areas are no longer suitable for the same purpose. i.e.: classroom offices. (probably need more furniture and space to conduct the class as before)

Functional zones for building is divided into:-

1. Academic
2. Administrative
3. Sleeping accommodation - students hostel
4. Sports Complexes
5. Staff's Accommodation
6. Infrastructure

Problems at school (34):-

A. Present double session school system.
B. High ratio of pupils to teachers (saturated condition)
C. Lack of local area schools.
D. Lack of classroom/ floating classes
E. Children are not motivated/tired and sleepy
F. Space constraint; for association meetings, societies and games
G. Students hanging around shopping complexes.
H. Students disassociate themselves from the classroom; furniture is scratched and damaged.
I. Building more schools within land constraints areas and unsuitable locations.

The information given is very useful for the professional as input to making decisions or making judgments. There is a need for explanation of the rank order of importance for future development and to convince the public about the importance of schools in the community.

To solve the problems, the Federal and State governments must cooperate to facilitate the building of schools in suitable locations. The ever increasing number of students must be accommodated along with the number of teachers, classroom, hostels, and schools. Also there is a need for replacement or reconstruction in the classroom using approved materials. Problems of termites
need to be solved. There are also some difficulties in fire fighting such as low water pressure and difficult to control the fire because of the wind factor (35).

Shortage of water supply can lead to bad impact not only to the hygiene of the place but also having no water to extinguish a fire. Therefore, the level of awareness should be improved among the school managements and authorities about the importance of safety and that the basic needs such as water should be provided.

Ethnic Primary School (36) also having problems with lack of classroom, restricted area and boundary for further development. Some of the existing buildings are in a bad shape, may collapse. Using canteen as classroom.

j. **Structure:** (Delphi discussion)

Work on maintaining the structure of the school building seems to be the most important issue that government is considering. It is because the result will be whether it is safe to use and can be maintained or it is not safe and cannot be maintained or should just be demolished and build a new building structure. This is more vital than any other aspect of building performance and can be convincing enough to be at the top of the rank order.

k. **Awareness**

Student's reaction towards the Fire emergency (37):

1. I thought they were not serious and continue bathing. But checking again when heard a loud noise.
2. I had always joked during fire drills that the only thing she would save would be the photo albums. I was just joking then, but now it's real.
3. She rushed out and saw smoking billowing and then she ran back again to her room and took the important personal items such as a wallet.

It's seems to be normal that people will checked the severity of the incident and then react again to safe their belonging what ever possible before leaving their rooms.
Among the problems which are considered serious and will be having higher impact to the fire safety situation in school are such as:

1. Discipline problems: smoking cigarettes, drugs, absenteeism, threatening teachers and illiteracy (38).
2. Schooling session (one or two session - morning and afternoon or either) (39).
3. There is a great interest in boarding schools and the hope from individual parents to send in their children into boarding school (40).

Other matters within the Education Ministry interest are:-

1. Need to build more boarding schools.
2. Need to upgrade the facilities in ordinary secondary schools.
3. To improve and sustain the level of education in school.

The educational establishment in Malaysia is facing several major problems particularly dealing with the need of constructing more school buildings to accommodate the increasing number of students each years. Other required spaces are the classroom, computer room, dormitory and laboratory.

2.8.4 Visits (Walkthrough Assessment)

2.8.4.1 School Problems

A. Nursery & Commercial Institutional Construction
   Normally it takes the original form of office or house and change it to nursery or tuition center.
   Problems:-Owner responsibilities, lack of fire safety facilities and normally no safety training at all.

B. Primary and Secondary School
   Problems:- Ad-hoc changes, putting responsibility on only one certain person.
C. Religion Based Secondary School
Problems:- Design, planning and administration (attitude), building age, materials used and building planning and design such as ergonomic and movement design plus functions (distance & environment).

2.8.4.2 Management, Administration and Maintenance of the Building

The continuing care of the building involves several aspects such as space use, intensity of occupants, rules, precautions and awareness of occupants need to be considered. Things to be considered:

1. Administrative point of view.
2. Level of awareness among staff.
3. Policies stated and suggestion from education administrators.

The differences observed between schools in terms of management, administration and maintenance of the school buildings can be categorised into the followings:

a) Headmaster/school leader point of view.
b) Schools grade
c) Financial capability or situation
d) Administrator perception on the safety responsibility
e) Allocation of responsibility and task.

Schools:- They are divided into 3 sessions

i. Morning session
ii. Morning and afternoon session
iii. Morning, afternoon and evening session.

Hostels:- Normally dormitory type. Easy for escape during emergency. They are being provided with double decker beds. This is to make sure that the students available can be accommodated. Double decker bed hostels are higher in density of occupants. Other problems created in private religious schools are that the separation between school buildings is very narrow, and the cooking areas are in the same space as the sleeping area.
The occupants of the hostels are aware about fire safety through the hostel regulations, talks and orientation. However, the interior layout and distance of the emergency doors to the bed, fire alarm, numbers of emergency escape and overall interior arrangement must also be evaluated for their performance.

Some cooking appliances available within the hostel such as electrical water coils, electric kettle, oil stove, gas stove must not be left unattended and always need to be supervised. In some schools the reasons for allowing the students to prepare their own food is because the food is not being provided or they cannot afford to pay for the food fees. For example the time for cooking normally around 6.00 am to 7.30 am in the morning, 12.30 pm to 1.30 pm during the noon, 6.30 pm to 8.00 pm in the evening and 10.30 pm to 11.00 pm at night.

Age of school building also is an important factor especially the physical structures and fire safety requirements. Not only that, the laboratory usage should be checked whether they are being used only as single function or double function such as doing experiment and as a classroom.

Accessibility for fire brigade:- There must be enough space for the fire brigade to reach all places in the school.

Rules at schools are being provided or displayed through the followings:-

i) Advertisement board
ii) In Classroom
iii) At the principals office
iv) School discipline
v) Announcement through PA. system.

Training is normally conducted when all the occupants are available and the time for having training may be divided into 3 session:-

a. Morning
b. Afternoon
c. Night
There are some suggestions for improvement such as:-

a. Install for more fire safety equipment
b. Need for more training to be conducted
c. Fire Brigade will have to provide more information
d. Form and train a fire safety team

Other dangerous activities:-
1. Burning garbage around hostels compound.
2. Smoking habits.

2.8.4.3 Current Design for Fire Safety at School

School buildings are generally referred to the Department of Public Works (JKR) (41). According to the drawing plans for standard Government schools, the design requirements are as follows:-

i. Roof:-
   - Roof tiles
   - Asbestos
   - Metal-zinc

ii. Structure:-
   - Reinforced-concrete.

iii. Wall:-
   - 100% Bricks
   - 50% Bricks & 50% Plywood or timber

iv. Windows:-
   - 95% louvre-glass with safety bar or with security grille.

v. Doors:-
   - Wooden doors only
   - Wooden doors with steel reinforcement.

The installation of the fire safety systems includes:
1. Fire Safety Precaution (Detection, Prevention and Protection)
2. Approval form the local authority and Ministry of Education
3. Requirements from the legislative point of view according to the Fire Brigade.
Things to be considered in improving the quality of life in schools:-

1. Need for more standardisation in the design of schools.
2. Renovation and materials used for construction must first be given an approval from local authority.
3. Build up the level of awareness concerning safety and fire.
4. Systematic management and maintenance need to be implemented.
5. Improving the type of fire safety equipment and installation by using more sophisticated equipment - may need maintenance procedures to be improved.

However, the main problems faced by the religious and private schools is the financial capability to carry out improvement.

Basically, the visits and discussion with the school's staff has brought to some suggestion for solutions such as:-

1. Management and supervision still need to be improved and overcrowding problems should be reviewed.
2. Planning and intake of new stock and occupants have to be controlled including providing sufficient finance.
3. Need to check on the fire safety equipment installed. Is it adequate?
4. Improve the level of awareness among administrators, children with more involvement from the Fire Brigade Department and produce more information about the importance of fire safety and the danger that can be created by fire.

2.8.4.4 Other Discussions:

Some of these discussions were made during my visit to the teachers hostel at Moray House, Edinburgh on the 27th February 1994. Most of the teachers has been teaching for more than 10 years from all types of different school backgrounds in Malaysia. Three items which are very much restricted in the hostels because of their inherent fire risks are:-

1/ Cigarettes
2/ Candles
3/ Mosquito coils

About the administrations, it was mentioned that there are still a lot of headmasters or school principals using the term "Follow my way or use the highway". However, that approach are now slowly becoming more of a compromise between the need of the school children and the targets or objectives of the school principals. They also did mentioned that the new approach on introducing the corporate management into schools was progressing smoothly. This is a very good sign for the future development of the schools as more people can really get involved and contribute towards school improvements. It is especially good for suggestions to principals to consider their actions for the implementation of regulations in any particular school.

Another important point was mentioned is that the maintenance of portable fire extinguisher and hose reel by fire authority can be irritating to them because in some schools, the portable extinguishers are under the required pressure or may be empty. From personal observation of some of the teachers in about 20 schools, there is no fire safety installation or equipment in the school libraries. However, schools in Malaysia are more likely to be easier for emergency escape when compared to British schools, because the layout plan of the schools in Malaysia are now more spacious and the constructions of the buildings is widely exposed to outside conditions. The following features of the school may however contribute to the level of fire safety:

1/ Less smoke hazards.
2/ The fire can be controlled easily from outside the buildings.
3/ Having two exit doors to an open air corridor for each classroom.
4/ The stairways is provided at both ends of the buildings to cater for the capacity of people flows during fire emergency and fire drills.
5/ Malaysian Schools are normally designed in such a way so that it is widely exposed to outside condition or more towards an open plan environment.
6/ However, the British school have more difficulties for escape during emergency because of the single door for each classroom, the flows of people is a bottle neck system where all the discharge doors will lead to a
single main exit. The spaces in the building are normally a controlled environment which involves more building services. This has an impact on the smoke hazard.

2.9  **Aims to solve the problems:**

1. To evaluate the education buildings for an acceptable standard.
2. To evaluate the level of fire safety awareness.
3. To establish the risk and safety factors within the schools and universities.
4. To establish the importance of buildings areas, functions and it's priority against fire emergency.
5. To produce an evaluation checklist for calculating the contributory points for an acceptable fire safety standard for school.

2.9.1  **Future Expectation In School**

Overall, the condition of the school would be changed in time and all the problems stated earlier also might create other kind of challenge for the fire safety design team, professionals and authorities. The general problems that are expected in the near future are as follows:-

a. Some private schools which are financially secured is sometimes much better than Government schools.

b. Private schools which have financial problems have a level of fire safety which is very much lower than Government school.

c. The regulation used normally from British Standard but then the environment is totally different. I.e.: climate, humidity, types of constructions.

d. There is no proper guidance applicable to schools but there is a general requirement for work places in the Building by-laws 1984. However, the need of standardised guidance to govern the development of the educational establishment is seems to be important.
The future school will be more advanced and the level of safety or risk will be more critical. The comfort level will be provided by a controlled environment, more electrical equipment and highly facilitated with good building services but with an increase in the loss impact. The value of the items within the space will be much higher than the present school building. This will be due to the introduction of multi-media equipments and telecommunication advancements.

There were several solutions proposed by the schools the headmasters during the walkthrough assessment visits:

1. Standards and proper design or materials use for constructions, such as reinforced concrete, bricks and tiles.
2. Planning for bigger and larger areas for future development.
3. Avoiding the location of different functions of the building in one area.
4. Hostel and classroom accommodation must be built separately.
5. Build up awareness about fire safety and comfort including the standards of educational aids. Open spaces should be used as a part of building separation and emergency access.
6. Introduce professional persons as part of education staff for maintenance, supervision and also advisor on fire safety and security.
References:


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26. Chin Y. S., "School to have new building" the New Straits Times (Newspaper), Penang, 18 October 1990.


37. The Star (Newspaper), “No Trick Or Joke This Time”, 19 Mac 1990.
3.0 Introduction

Fire safety engineering is one of the technological aspects of the overall performance of a complete building and is, therefore, part of the physical solution of building design. Other objectives of building design will be the aesthetic, functional and economic issues. However, in order to solve the fire problems in buildings, there are 5 major considerations on building performances that need to be made. They are described by John Zeisel (1) as:-

1. **Effectiveness** refers to the degree to which a particular environmental or physical attribute reduces costs and increases the qualities it is intended to achieve.

2. **Well-being** refers to the qualities of life that a building provides to employees, other users, and the organisation as a whole. Examples are occupants satisfaction, comfort, job performance, organisational productivity, physical health and life cycle building cost analysis.

3. **Control** refers to the way in which environmental elements in a building are constructed to accommodate and respond to the needs of building users. In total building performance control is a major theme because it constitutes a complex set of regulatory mechanisms that keep the building functioning.

4. **Incremental change** refers to the flexibility to accommodate the coming modification into the norm of a building without causing any major cost or lowering the quality of well-being of building users whilst maintaining the total building performance.

5. **Major changes** in buildings take place because of changes in knowledge, technology and even the use of the building. Examples of such changes are: the introduction of solar energy or passive system, change from closed to open office planning and back again and innovations in office automation and car park to flats.
One way to check building performance is to do an evaluation. An evaluation can take be undertaken using several forms. These include techniques such as occupancy analysis via questionnaire, professional judgement and perception, experimental analysis, and risk and safety assessment. The development and use of checklists are acceptable for checking the building regulation requirements may be valuable aids to the identification and assessment of deficient performance. However, a target must be set for each of the performance parameters, for example fire safety as in the present context of educational establishments. The title for this research has already clearly shown the purpose of the whole exercise and the importance of identifying and reaching a target. In this context the target is the fire safety policy of the educational establishment that needs to be established among all the professionals and authorities in Malaysia.

The fire hazards and accidents within the school have been well known and have caused a lot of damage to life and property. The problems within the educational establishment are taken seriously by the public and by individuals because of the impact that results from such an accident not only involves the individuals but also politicians. Then the hazards are considered to be the issues of the community, local government, national and international.

This is where the local authorities and other bodies play their part. They feel the need to ensure that the buildings are safe and secure by introducing the regulations and laws. And in most building regulations there are divisions and parts where one of them is the statement of performances which involved policy, objectives, tactics and components of performance. Therefore, it is important to include the building regulations and requirements, human factors and risk assessment in this study in order to understand the whole process of evaluation.

3.1 Building Regulations and Performance Statement

Safety is very hard to define and quantify where standards of performance are elusive. Safety may be defined as the state of being free from danger. Fire problems is something that is very unpredictable, non-static and usually will cost a lot of money to be able to run any real size experimental work and not even to
repeat the test. The behaviour of the fire differs from area to area depending on the availability of the fuel, heat, oxygen and potential to spread. Ian Appleton(4) said that, consequently the regulations for fire safety are definitions of requirements for components of buildings which are judged to achieve an acceptable standards, instead of defining what the standards are. He (4) continues saying that the regulations, form a set of constraints which are not expressed as a measurable standard for the whole building, but as hardware requirements for individual elements of the building.

It is worth examining the process through which regulations should derived. A fundamental approach to regulations should start with a statement of the objectives of the regulations where it should describe how the building is to perform in terms of the way it functions in a fire. The functions should be expressed (if possible) in numerical terms such as the building safety function should be the probability that one individual is killed by fire per annum(4). The performance requirement or standard is a value of this probability that is deemed to be an acceptable risk. Such a performance requirement may vary between buildings and it is probable that it would change with the economic wealth of the nation ((4) - pp 25-26).

In order to achieve the design of the building to this type of standard or performance requirements of the regulations, a valid procedure is needed for predicting the performance of buildings from its component parts at the design stage. Among the relevant steps to meet the demands of such a scheme are the measurement of safety and the determination of acceptable levels of risk and how much does it cost to achieve them and the behaviour of people in fires (4). This requires research into attitudes to and perceptions of risk, disasters, safety, health and welfare. It is best to establish the level of awareness and response of the building occupants towards fire emergencies via questionnaires and also the buildings' condition in terms of fire safety requirements through the current legislation or regulations and professional perceptions before an evaluation of fire safety of a building within an establishment can be done effectively. This is covered within the chapters 4 and 5 of this thesis. So it is essential to know what exactly each of the applicable regulations and documents require as a contribution to the level of safety for a building.
3.2 Document Analysis

There is a standard stated specifically for the educational establishment which directly focused for the fire safety need of a school building. In the U.K. this is covered by Building Bulletin 7 (34). However, other building regulations also will be discussed within this chapter to get the overall perception of the performance requirements for the educational establishment particularly involved with schools before next step in producing an evaluation checklist can be done.

The educational establishment is not only the concern of the government but it is also the concern of the public. Schools have always been the most important public building in a settlement and an important component of the development of the country. Matters that are normally looked up by the public would be the level of education being provided including the safety provision given to their children while being within the premises such as a school or a university. The pressure for safety will be at it highest whenever there is a fire emergency and particularly one involving loss of human life(s). It could became the major issue even to the international level of politics of the nations. There are several bodies that are looking into the enforcement of the safety requirements, in this matter, fire safety. This is not only to ensure that the fire safety requirement is fullfilled but also to make sure that the quality of system provided and it's performance meets the type of risk or hazards. This can be done by implimentation of the macro assurance system into fire safety engineering. In order to achieve the expectation of fire safety requirement in any buildings, the social groups and organisations ranging from the government, insurers, quality certification bodies, building authorities, fire authorities, and trade and professional bodies could play a role.

3.2.1 Building Bulletin 7

Globally, the education issues are very important, therefore some countries like Great Britain have taken the steps to overcome the fire safety problems for their educational buildings by developing and publishing guidance, for example, Building Bulletin 7. The guidance on fire safety in educational buildings; “Fire and the design of educational buildings” was published by the Department for Education and
Employment (6). It was first published in 1952 but the current sixth edition has been updated to complement the Approved Documents issued with the 1985 Building Regulations for England and Wales. Paul Stollard (22) also wrote that the Building Bulletin 7 has legal status in England and Wales only and in effect, provides the Code of Practice for fire safety in educational buildings. There has been an exemption for educational buildings from applying the requirements of the Building Regulations(5). This exemption applies to the purpose of a school or other educational establishment similar to it. Eventhough the educational establishment is exempt from the Building Regulations by virtue of the approval of Building Bulletin 7 by the Secretary of State for Education and Science. School buildings, in particular, are still referred by the Education (School Premises) Regulations 1981 together with Bulletin 7 in terms of fire safety requirements. The 5 elements concerned on the fire precautions provision that involve design and construction, under safety protection are (1):-

a. the safe escape of occupants in case of fire and
b. their health and safety in other respects are reasonably assured.
c. the likely rate at which flames would spread across exposed surfaces;
d. resistance to fire of the structures and of the materials used therein and their other properties and
e. the means of escape in case of fire.

Building Bulletin 7 is applicable to new building construction or adaptation and also remodelling work in the existing buildings. It is not applicable to residential accommodation as this part requires the application of both the standards of the Building Regulations and the requirements of the local fire authority. However, the main emphasis of this bulletin is to ensure the safe escape of the occupants of the building in the event of fire, through proper design and construction. Other requirements covers include:-

i. The construction of a building as a whole and recommendation on how to limit damage to the structure.
ii. The resistance of the surface of the construction to the rapid spread of fire.
iii. Provision of warning systems
iv. Fire fighting equipment
v. Everyday precautions against fire
vi. Prevention through careful design, management and maintenance to limit the fire damage.

This means that it is a Government priority to make sure every single decision made for the building of schools or any educational establishment buildings regarding the fire safety requirements are being considered. The Government have to be responsible for the safety of the building occupants and the building itself and this will reflect the Government credibility and concerned on it's people and the general community who has put their trust by the election to govern the country. It doesn't mean that the government can escape from fulfilling the safety requirements because all these consequently will have an impact to the overall implementation of the regulations and legislations. The government has to be the best example to start with the enforcement of the existing regulations requirements.

Other Building Regulations that are being used by the local authority or fire brigade to cover the different parts of the educational buildings which are used as offices or shops and residential accommodation will have other documents to refer to.

3.2.2 Fire Precaution Act 1971

Other buildings within the schools may have a different kind of function or purpose other than educating or administrating. The fire authority in Malaysia also uses the Fire Precautions Act 1971 as a reference to accommodate buildings with fire requirements. The principal fire safety control in some occupied premises is the Fire Precautions Act 1971(8). An aim of the Act is to improve the standard of fire protection for people in existing buildings on a consistent basis in relation to a variety of uses. It was stated by Ann Everton and Gordon Cooke(9) that it is the first Act to deal exclusively with the problems of fire. They(9) also said that the Act is concerned only with the protection of life in the event of fire in an existing building and achieves this through ensuring that adequate means of escape are provided
including adequate general fire safety and related fire precautions in premises within its scope. Buildings covered by the Act in Malaysia are as follows (9):-

a. recreation, entertainment or instruction or for any club, society or association.
b. teaching, training or research
c. institutions providing treatment or care
d. any purpose involving the provision of sleeping accommodation
e. any use involving access to the building by members of the public, whether on payment or otherwise
f. the use of the premises as a place of work (since the enactment of the Health and Safety at Work etc Act 1974)

The requirements of the Act are (9): means of escape and their safe and effective use; means of fire fighting; and means of giving warning in case of fire. All requires to be a reasonable standard and fire certificates should be granted once the inspection of the premises achieved the standard or up grading work should take place. The certificates also impose requirements as to maintenance, instruction and training of staff, limitation of numbers and observance of other fire precautions.

It was stated (8) that fire safety precautions in places of work are controlled mainly by the Fire Precautions Act 1971, as amended by the Fire Safety and Safety of Places of Sport Act 1987. The Fire Precautions Act requires certain designated premises namely factories, offices, shops, hotels and boarding houses, and railway premises to have a Fire Certificate. An existing Fire Certificate issued under the Factories Act 1961 (10) or the Offices, shops and Railway Premises Act 1963 (11) only if there has been no material change to the premises.

Among other relevant guides used by the fire authorities to ensure consistency of approach in compliance with the Fire Precautions Act are:-

- Code of Practice for Fire Precautions in Factories, Offices, Shops and Railways Premises not required to have a Fire Certificate (12)
- Fire Certificates (Special Premises) Regulations 1976 which must be issued by the Health and Safety Executive for premises which manufacture, use or store certain highly hazardous materials (13).
• Guides to the Fire Precautions Act 1971 used for Hotels and Boarding Houses requiring a Fire Certificate (14) also Guides for Offices and for Factories.

3.2.3 Approved Document B

Eventhough the Approved Document B is only applicable to the buildings in the England and Wales, some of the recommendations and requirements on fire safety design of a building could be very useful for these evaluation studies of the school buildings in Malaysia. Approved Document B is not obligatory but only a guidance document which enables compliance with the requirements of the building regulations in England and Wales. The status of approved documents is defined in Section 7 of the Building Act 1984(16). The approved document which relates to fire safety, deals with the following requirement from Part B of schedule 1 to the Building Regulation 1991(17). Refer to Table 3.0: Fire safety Requirements from Building Regulations 1991(17).

The provisions set out in the documents is under B1 to B5, deal with different aspects of fire safety, with the following aims:-

B1: that there is a satisfactory standard of means of escape for persons in the event of fire in a building.
B2: that fire spread over the internal linings of buildings is inhibited.
B3: to ensure the stability of buildings in the event of fire; to ensure that there is a sufficient degree of fire separation within buildings and between adjoining buildings; and to inhibit the unseen spread of fire and smoke in concealed spaces in buildings.
B4: that external walls and roofs have adequate resistance to the spread of fire in the external envelope, and that spread of fire from one building to another is restricted.
B5: to ensure satisfactory access for fire appliances to buildings and the provision of facilities in buildings to assist fire fighters in the saving of life of people in and around buildings.
The guidance in the document as a whole should be considered as a package aimed at achieving an acceptable standard of fire safety. It also gives a kind of performance analysis for the fire safety requirements. An example of an overall approach to fire safety can be found in several parts of BS 5588: Fire precautions in the design, construction and use of buildings. Parts of this standard are referred to directly in Approved Document 'B'. Building Regulations are intended to ensure that a reasonable standard of safety is provided, in case of fire and other documentation from authoritative sources help to define the technical details that should be incorporated in the building.

3.2.3.1 Guides to the Fire Precautions Act 1971 1: Hotels and Boarding Houses

Guidance in the guide (15) may be important as the information can be applied directly for improving the fire safety standards in hostels that are part of a residential school. Enforcement of the Act ensures the provision of adequate means of escape and related fire precautions in the premises within its scope and has been entrusted to the fire authorities. The Act is concerned only with the protection of life in the event of fire and non-compliance attracts criminal penalties. When fire breaks out in a building in which people are present, the primary need is for those people to be able to escape safely and quickly even before the fire brigade arrives. The Act designates uses of premises which involve members of the public being present in any number in which they would be specially at risk in the event of fire. The detailed list of uses is similar to the Fire Precautions Act 1971, Part 1:Section 1(2) page 4, and a complete list is given in the Appendix A of the Act, page 19 (15). The 5 categories of use are:

a. Public residential accommodation
b. Institutions
c. Places of public entertainment and recreation
d. Places of instruction
e. Places other than buildings.
The Act is applicable in the category (a) and (d) of the above for the educational establishment particularly the residential schools. The Part II of the Act (15) is covering 4 areas of concerned:

1. **Means of escape**: It covers the travel within rooms; travel from rooms to stairways or final exits; travel within stairways and to final exits; general requirements (such as ventilation, fire resisting doors, fire exits and signage) and emergency lighting.

2. **Means of giving warning in case of fire**: The system installed should be:
   i. readily available at all times
   ii. capable of being operated without exposing ny person to undue risk.
   iii. perceptible throughout the premises, and capable of waking staff and residents.
   iv. distinctive in that it will not be confused with any other signal in the premises.

3. **Fire fighting equipment**: It is for the use of the building occupants for fighting fire. Among the equipment that can be installed are hose reels and fire extinguishers. The design requirements are also given in the Act.

4. **Fire instruction and drills**: The information should be readily available to all occupants, the staff should be adequately trained and able to instruct during the event of fire. The instructions should be available in writing. Training and instruction including organising details should be well recorded.

It is very important to comply with the requirements of the Act(15) which involve fire safety management to deal with the main objective of the fire policy for any building that is life safety.

**Draft Technical Guide to the Fire Precautions (Place of Work) Regulations**

The aim of this directive is to encourage improvement in fire safety in the workplace and reduce or eliminate the risk of fire. The Regulations will apply to all places of
work which are covered by the definition of premises in section 43 of the Fire Precautions Act 1971 and have not been exempted from the Regulations(19). This guide is a technical document of basic principles which gives technical advice on how the architects, fire authorities, in-house fire safety advisers and other professionals can arrange the building to comply with the Regulations in the field of fire precautions by describing appropriate technical standards. This guidance is not being used directly for any fire safety design requirements for the educational buildings because the educational establishment have the Department of Education and Science Building Bulletin 7, Fire and design of educational buildings (HMSO 1988)(18) as the reference. However, this guidance is very useful to look at as a fire risk assessment method in the effort to produce the fire safety evaluation checklist and procedure for the educational buildings in this study.

3.2.4 Other Relevant Documents

Even though a Malaysian Standard is available, some of the conditions still depend on the standard set by British Standards which have been used in most Building Regulations. Building Regulations are made for specific purposes; health and safety, energy conservation and welfare and convenience of disabled people. Standards and technical approvals are relevant guidance to the extent that they relate to these considerations. However, they may also address other aspects of performance such as serviceability or aspects which although they relate to health and safety, are not covered by the Regulations. Approved Document B as explained in paragraph 3.2.3, is related to fire safety from part B of Schedule 1 to the Building Regulations 1991 which replace the Building Regulations 1985 (SI 1985 No. 1065).

In Malaysia, there are few other guidelines which are applicable directly to the needs of fire safety at schools. The guidance on control and requirements of fire safety at schools in Malaysia are based on the Uniform Building by-Law 1985 and also the Fire Brigade Act (Akta Bomba) 1988. The aims of the guidance are to ensure that all the preparation of documentation, installation plans and other requirements for fire safety can be produced properly and able to be approved by
the authorities involved. They are being divided into 3 parts which are inter-related to one another:-

- Part1: Plan Submission Requirements
- Part2: Requirements of the Department of Fire Brigade
- Part3: General Requirements.

In general the Part I, Part 2 and Part 3 can be referred to the Appendix 1.0. Most of the responsibility for fulfilment of the guidance requirements by Fire brigade are given to the local authorities such as the General Works Department (JKR) of the state or special unit. However, Part 2 can be divided into 6 sub-divisions which cover:-

A. Schools Standard Plan, hydrant and accessibility for Fire Brigade appliance.
B. General Requirements For Fire Safety at School: It considers the requirements for building works, portable extinguishers, electrical installations, fixed mechanical installations and travel distance within a building.
C. Standard Fire Safety Requirements For Laboratory: This includes the building works and fire resistance plus building materials, portable extinguishers and electrical installation requirements.
D. Canteen building: Requirements cover as in (b) or (c).
E. Assembly hall building: Requirements cover as in (b) or (c).

Refer to Appendix 1.0 for the details of the fire safety requirements covered by the guidance.

### 3.3 UNIFORM BUILDING BY-LAW 1984 (Law of Malaysia)

The other key reference that most building construction in Malaysia being referred to, next to the Malaysian Standard (MS), British Standard (BS) and Acts, is the Uniform Building By-Law 1984 [G.N.5178/85] of Malaysian Government(20). It was been compiled by Legal Research Board and in the exercise of the powers confered by section 133 of the Street Drainage and Building Act 1974, the Minister/State Authority.
3.3.1 Fire Safety Assessment: An Analysis On Building Regulations
(Based on the Uniform Building-Laws 1984, Law of Malaysia)

The scope of this study is based on the data given by the building regulations stated in Uniform Building By-Laws 1984 of Malaysian Government. The whole process will determined the level of performance of each system suggested by the regulations, design and the requirements of fire safety for educational buildings. This is important to most parties involved in decision making regarding life and property safety. The purpose also goes to the improvement of educational buildings for children in Malaysia according to their comfort needs in future by comparing with the existing standard buildings. Therefore, the level of fire safety in buildings will also need to be improved and careful study will assist the designer or owner in terms of costing capabilities within the options available to them. There is also an effort to distinguish the importance of certain performance in terms of the regulatory context.

QUESTIONS:-

a). Is the Regulations/Act adequate for the designer teams to perform or complete their task on fire safety for any construction project before and after commissionning?

b). Are the regulations easy to understand and to use by the professional and non-professional in order to tackle the fire problems?

c). How good are the existing regulations?

d). Which fire risk assessment is considered to be better in term of simplicity and accuracy?

e). Do we really need to upgrade the condition of the building and perhaps the building requirements as well?

f). Do the educational establishments really need to be safe from the danger of fire?

In order to analyse the content of the Building By-Laws for the assessment purpose, 9 major groups has been identified in the document. They are as follows:-

1/ Building Regulations/Acts
2/ Decision Organisation
3/ Buildings Categories/Occupancy
Each of the groups stated are being analysed in terms of their relevant words which occur in the text of the document. The frequency of occurrence for each of the words are used as assumptions of priority under each of the groups. This is useful for the authority officer to have a better understanding about building and the fire safety requirements for a building in total starting from the beginning of design stage until the commissioning of the building to the owner. Not every single group will be used for the Fire Safety Requirement assessment studies but at least the interaction of each group can be seen clearly and this may help to make the study process much more easier to be analysed.

<table>
<thead>
<tr>
<th>BUILDING REGULATIONS/ACT</th>
<th>FREQUENCY POINT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/ BS / BSCP</td>
<td>40</td>
</tr>
<tr>
<td>2/ AUSTRALIAN STANDARD</td>
<td>6</td>
</tr>
<tr>
<td>3/ MS / MSCP</td>
<td>6</td>
</tr>
<tr>
<td>4/ BUILDING ACT</td>
<td>3</td>
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<tr>
<td>5/ FACTORIES ACT</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3.0: References Priority of the Building Regulation in Malaysia

The thorough study of the Building By-Laws has given the chance to make an assumption on which Standard and Building Regulations are being used widely in setting up the whole purpose of the buildings requirements.

The British Standard and British Standard Code of Practice (35) are the two major contributors for the foundation of building construction in Malaysia. It does show that the British Standard(BS) and Code of Practice(BSCP) are the most established guidance that exists in Malaysia. They are widely used throughout building design in the Malaysian buildings construction scenario, even though the Malaysian Standard(MS) and Code of Practice(MSCP) is replacing, gradually, the BS /BSCP.
However, the use of other Buildings Standard in the Building By-Laws document involves the Malaysian Standard, MSCP and Australian Standards (Aus.S). Malaysian Government is implementing its own building regulations through Building By-Laws and yet the existing BS and Aus.S are both still useful for the safety construction practices in Malaysia mainly dealing with fire safety requirements. Besides that, Building Act 1974 and Factory Act 1967(38) are also being used in setting up the buildings regulations in Malaysia.

<table>
<thead>
<tr>
<th>DECISION ORGANISATION</th>
<th>FREQUENCY POINT</th>
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</thead>
<tbody>
<tr>
<td>1/ LOCAL AUTHORITY</td>
<td>40</td>
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<tr>
<td>2/ FIRE AUTHORITY (DGFS)</td>
<td>29</td>
</tr>
<tr>
<td>3/ ARCHITECT</td>
<td>18</td>
</tr>
<tr>
<td>4/ ENGINEER</td>
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<tr>
<td>5/ FIRE BRIGADE</td>
<td>12</td>
</tr>
<tr>
<td>6/ OWNER</td>
<td>4</td>
</tr>
<tr>
<td>7/ PLANNING AUTHORITY</td>
<td>2</td>
</tr>
<tr>
<td>8/ PUBLIC</td>
<td>2</td>
</tr>
<tr>
<td>9/ MINISTER/STATE AUTHORITY</td>
<td>1</td>
</tr>
<tr>
<td>10/CONTRACTOR</td>
<td>1</td>
</tr>
<tr>
<td>11/FORESTRY DEPARTMENT</td>
<td>1</td>
</tr>
<tr>
<td>*12/OCCUPANCY</td>
<td>19</td>
</tr>
</tbody>
</table>

Table 3.1: Decision Making Organisation

In this particular division, most of the listed organisation or personnel are those who involves in making decision for any building construction process. They may involve directly or indirectly with the whole construction project. However, one of the listed items that is, the occupancy, should not be in this group because it is applied more for types of buildings usage or building categories.

The frequency given for each item shows that from No.1 until No.12 seems to be in the logical sequence. This gives the priority to the Local Authority to approve any building construction projects which have been handed in by any developers. This responsibility held by the Local Authority is the reason for most of the buildings plan need to be submitted to the Local Authority and the Fire Authority for their consent or approval. The professionals such as the Architect, Engineer, Quantity Surveyor and Draughtman are seems to follow the list of important people in the construction field. Therefore in the process of designing a buildings, a "brains storming group"
should be conducted among the professionals whom may be working as the Local Authority, involving the Fire Authority and with the architect as the chairman.

The brains storming period especially in design stages are very useful for the correct interaction amongst all the buildings requirements throughout the construction process until the commissioning and maintenance period. Normally, the architect will be doing the architectural design and the engineers will design the required services including fire safety installation, structural, electrical and mechanical parts. Architects and engineers should be working closely for having better design solutions. However, the owner will be involved indirectly almost throughout the period of the building design and construction where they dealing with financial capabilities and other requirements. This is important because the professionals will have to advise the owner with all the possibilities systems available for building design in order to achieve the objective of the building according to the owner needs. If the Fire Brigade is an entirely different body to the Fire Authority then the Fire Brigade function is to suggest the type of fire safety requirements particularly accessibility for the Fire Brigade during any emergency concerning the building.

The Planning Authority may be a part of the Local Authority practices in certain areas and normally they will ensure that the types of buildings categories are built on a proper land use according to the Structure Plan of the whole area or country. Therefore, the public have their rights to give comments or protest on any building constructions which are not according to the proper land usage and that could cause some changes to the surroundings or impact on environmental issues.

The Forestry Department contributes in the monitoring or control of the areas which are supposed to be protected as reserved forest from being abused by any irresponsible bodies. Moreover, the involvement of the Ministry or State Authority may be vital to certain decision made earlier by previous group or personnel. They normally can give the right to approve any project for the sake or benefits of the country and people but not for the sake of individual interest. However, they should be advised by the professional and the Local Authority regarding the building projects. Corruption should be avoided and any personal interests are not allowed
prior to the involvement of any politicians where a building failure can be against
them and their reputation.

The table of frequency points for rest of the group 3,4,5,6,7, 8 and 9 are given in
the Appendix 3.0. The arrangement of the words within the given group still need
to be rearranged but the table gives a quick reference to acknowledge the relevant
relative contribution(s) from the components. For example, from Table
3.6(Appendix3.0): Materials for Construction gives the three common building
materials used in building construction in Malaysia, those are wood or timber,
concrete and steel.

3.3.2 Fire Precautions Requirements for Building in Malaysia

In order to be able to produce the evaluation procedure on fire safety for the
educational establishment, the first step taken within this research is studying the
contributions of the building regulations available in terms of tackling the problems
of fire through the following stages:

a). Design Stage
b) Constructional Stage
c) Commissioning Stage (immediately before and after occupation)
d) Fire Accident Stage
e) Recovery Stage
f) Cost Effectiveness and Maintenance Stages
g) Continuation of Mission Stage

The study aims to analyse the intentions for fire safety suggested by the building
regulations, where the requirement for fire safety is considered the acceptable
standard to cater the fire hazards problems faced by most buildings in the past and
in the future. Then next step is to concentrate on the suggested fire requirements
in the regulations before any comparison is made against the total fire requirements
for buildings. By referring to the Uniform Building By-Laws(20), there are 9 parts:-

Part 1 : Preliminary
Part 2 : Submission of Plans for Approval
Part 3 : Space, Light and Ventilation
Part 4: Temporary works in connection with Building Operations
Part 5: Structural Requirements
Part 6: Constructional Requirements
Part 7: Fire Requirements
Part 9: Miscellaneous

Basically in Part 1, all the major lists of important words in the aspect of fire safety is given the interpretation clause.

This is followed by Part 2, which is concerned more on the design requirements that must be fulfilled before any building or construction is erected. This part is important to look into for fire safety purposes as we can notice that, the first contributions towards fire hazards is because the requirement of fire safety design is not taken seriously by whoever approved the building plans. It does concern human (occupation) health and safety including the building services.

The design requirements are concerned with the topics of:-

i) Accessibility
ii) Distance between buildings
iii) Constructional dimensions (indirectly the resistance of fire and stability of structure)
iv) Materials used
v) Services required
vi) Fire safety (The details are given in part 7)

So, the design stage is very important as part of fire safety and the qualified persons should be the professionals who are expert in their own field e.g Architects, Engineers, Draughtmen and Quantity Surveyors. Then, the stage of approval of design for those whom are working in the local authority. They should be as competent as the qualified professionals except assistance is available throughout the assessment for plans approval. This will ensure that plans are being studied thoroughly and carefully. In the construction stage, the professionals need to supervise the work done by contractor so that it is being built according to the
approved plans. But yet, whose is the responsibility for the accuracy and correctness of the construction, who should be the first to be blamed for errors? Should it be the Local Authority, Professionals, Contractors or owners.

This is the reason why the owner needs to do some assessment about the safety of their building individually or by getting help from the professional i.e. fire brigade officers or specialist in this area. However, in the last part of Part 2 of this regulations, it is mentioned that the professionals are the ones who are responsible for any building failure as they the ones who know best about buildings.

This part of the study (Part 3), is to consider what should be among the major factors that contribute towards the fire safety of the occupant and the building. It does take into account the importance of buildings distribution and the surroundings that may cause more damage or harm during fire hazards resulting from the lack of open space and distances between buildings. i.e: If the arrangement of houses/buildings are to close to each other then building to building fire spread may be easy, lack of space for fire brigade accessibility in fighting against fire, there is no adequate air passage in those areas or rooms incase of fire, particularly dealing with smoke, if the natural ventilation is not properly available then it will result in the space becoming increasingly uncomfortable because of odour, body temperature, lack of air movement and decrements in mental and physical activities. The distance between buildings should also be considered for acoustical problems, some forms of buildings projection must also be guided or controlled so that it does not cause other buildings which are attached or around being deprived of their natural lighting during the day time.

In this Part 3, it is stated the authorised body which is involved directly for the implementation of the building regulations is the Planning Authority and the Local Authority. Therefore, provision of fire safety in buildings must also take into consideration the design and layout of the building before the construction can be approved by the authorities. This is very important for the occupant during escape and for evacuation purposes by the emergency services.

Part 4 is considered important for the fire safety requirements in the stage of constructing the building. However, the concentration of fire safety is focusing on
the whole site relating towards the workers, buildings under construction, services to the site, buildings which are existing at the nearest site and the surroundings. The responsibilities are upon the building contractor and consultants who are involved directly for the work progress. Some of the facilities are roadside drain clear, existing cables, utility, equipment, warning marks and signage, first aid, ensuring that hydrant points not obstructed by such hoardings/ materials, etc. This part must also involving the functions of enviromental officers as it will ensure that the pollution level is under supervision particularly dealing with surface water, air, and vegetation.

Part 5 is an interesting part of study which involves fire safety in terms of how much fuel in building materials that will contributing towards fire severity by calculating the load of combustible materials imposed on the particular building. Therefore this Part 5 seems to be more concentrated on fire prevention passive systems dealing with building structural components.

Part 6 is a very important in terms of fire safety during the construction period, also. In addition, it provides some information on fuel types that are used for construction and the sources of ignition that can contribute towards fire hazards in building. This information will assist the designers and builders to give serious consideration about the probability of fire occurrence in the building and what are the fire resistant materials to be used for certain parts of the construction. Regarding the accessibility provided during construction and after commissioning is very important in order to understand the best possible way of getting out of an area in case of fire incident. Some of the list mentioned in this part are sub-component or involved indirectly with the fire safety requirements in buildings for the life and property safety including continuation of mission which is important during the recovery stage.

All the requirements for fire safety of a constructing or constructed buildings are given in this Part 7. It involves the design stages, construction stages, usage stages which mix both the passive and active system(s) in a building. However, most of the requirements for fire safety are more concerned with the construction of the building without considering any assistance from any external fire safety technology. That means the construction of a building itself is already a step to
prevent any fire hazard and to achieve life safety, property protection and continuation of mission. Therefore, with good design and good materials (fire resistance) for the construction of a building will help to minimise the cost of any extra fire safety system(s) to be installed. This part is very much concerned about it's structural stability and integrity. Important for recovery and mission continuation purposes and for evacuation during emergency.

This is a support system for the buildings in case of fire hazards. Most of these aspects in Part 8 are extra and suggested installations (portable or fixed) of systems which could help to detect, control and extinguish the fire in a building. The systems suggested are really important so that the life and property safety, continuation of mission and recovery objectives are ensured. However, without a proper study on which system to be installed or to purchase, it may be not the correct system to assist the extinguishing of fire and may also cost the owner of the building more than expected. Therefore, a careful study about the existing ignition sources, activities and proper system needed for the type of hazard is very important.

**Part 9**, refer to (20).

Prevention of conflagration and reduction of damage, life safety and property damage, will be secured by introducing a proper fire safety installation. Hopefully to the minimum requirement of installation and budget spending. Therefore, to avoid and reduce more vital accident caused by fire and also to reduce the cost of recovery in case of fire, than the building itself needs to be protected by passive and active systems available. These will result in a non serious fire hazard and a situation where it will be easier to recover after a fire for the continuation of mission. It also helps to limit the environmental pollution to the surrounding areas or globally and build more confidence in the public about the importance of having fire safety requirements fulfilled.

All the aspects of fire safety requirements have been studied thoroughly in the process of building construction. Safety of the occupants and property in the particular building will only be realistic if all the actions required are taken into consideration starting at the beginning of the design process through
commissioning, alteration and until the maintenance process taken place. However, the details of each stages have been explained in the analysis of the required building standards on fire safety. In order to ensure that all the actions are done, the responsible bodies must make sure that their job is not corrupted and all the requirements are fulfilled. The list of responsible bodies or organisations are given as Table 3.2 in section 3.3.1.

### FIRE SAFETY

<table>
<thead>
<tr>
<th>Stages of Fire</th>
<th>Building Construction</th>
<th>Activities, Actions &amp; Requirements</th>
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<tbody>
<tr>
<td>Safety Development</td>
<td>Process</td>
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<td>I</td>
<td>Design &amp; Approval</td>
<td>- Assessment on Fire Safety (Regs &amp; Act)</td>
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<td>- Performances</td>
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<td>- Reliability</td>
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<td></td>
<td>- Safety Plans &amp; Supervision</td>
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<tr>
<td>II</td>
<td>Construction</td>
<td>- Health and Safety on Site (workers and staff, visitors)</td>
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<td></td>
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<td>- Layout Plan</td>
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<td></td>
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<td>- Housekeeping and Material distribution on site</td>
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<td></td>
<td>- Security and Monitoring on site</td>
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<tr>
<td>III</td>
<td>Commissioning</td>
<td>- Introducing new system if possible</td>
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<td></td>
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<td>- Introduce Support System</td>
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<td>- Occupancies Responsibilities</td>
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<td>- Checking and Maintenance</td>
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<td>IV</td>
<td>Accidental Coverage Recovery</td>
<td>- Insurance for Lifes &amp; Properties</td>
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<td>- Structural Stability</td>
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<td>- Performance Assessment</td>
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<td>- Notify the Safety and Risk Factors</td>
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<td>- Loss Estimation</td>
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<td>V</td>
<td>Improvement, Rebuilding or Maintenance or Alteration</td>
<td>- Rechecking theRegs, &amp; Acts, Maintenance</td>
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<td>- Layout, Boundary etc</td>
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<td>- Building Structural</td>
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<td>- Building Services</td>
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<td>- Building Environment</td>
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</table>

Diagram 3.0: Fire Safety and Building Life Cycle
The listed bodies are directly mentioned by the Building By-Laws in the Malaysian context for buildings construction. The Diagram 3.0 above is to summarize the involvement of fire safety throughout the building life cycle.

Another factor besides building regulations that ought to be considered in understanding the whole process of producing fire safety evaluation procedure for educational establishment is the human factor. Building regulations are mainly written to cater the need of the human within the environment either regarding the safety or health. Most regulations were produced after an accident which involved the loss of human lives. The fire policy for educational establishments to be achieved are focused on the following objectives:-

1/ Life Safety
2/ Property Protection
3/ Mission Continuity
4/ Environmental Protection
5/ Public Anxiety
6/ Economy

These objectives are among the most important targets to be achieved by the studies and the end result will produce a safe building and environment for the whole educational building. Besides, prevention of conflagration and damage reduction in terms of lives and properties are very much interrelated with the reduction in cost of the effective fire safety system, installation and also post-fire recovery purposes. In order to achieve each and every single of the objective, serious and critical studies on the fire safety requirements need to be done by producing an assessment list of fire safety requirements for buildings against fire. This study is particularly involves school buildings. The importance of the study scope involving secondary schools has been confirmed through the discussion organised among the Delphi Group and described in Chapter 5.
3.4 Human Factors: Introduction

Human factors are not something that can be eliminated in design and evaluation work particularly involving the safety policy. Since the educational establishment buildings are built orientated towards people and a principal concern is the safety of the occupants. The understanding of human factors for fire safety engineering is very important. It was said by Julien M. Christensen(2a) that:

"In their interactions with environmental features people had recognised that their effectiveness could be increased significantly by even slight modifications in those features. Improved controls and displays-or "knobs and dials" as they are often termed- are modern example of the profound effects that relatively minor changes in the environment can sometimes have on performance."

Even though the existence of machines and modern technologies, performance depend on how the human reacts towards the local environment and related appliances. Therefore, a series of human factors must be considered in the design of the questionnaire on the level of awareness and the occupancy contributions towards fire safety within the educational establishment. Also in the production of the fire safety evaluation procedures where human factors should not be excluded as they contribute mostly throughout the overall studies.

The official definition of industrial engineering, as adopted by the American Institute for Industrial Engineers in 1961(3), reads:

"Industrial engineering is concerned with the design, improvement, and installation of integrated systems of people, material, equipment and energy. It draws upon specialised knowledge and skills in the mathematical, physical and social sciences together with the principles and methods of engineering analysis and design to specify, predict and evaluate the results to be obtained from such systems. Weston, 1961. (emphasis added)"

The definition reveals a sensitivity to the need to consider the social sciences as well as the physical sciences in the development of modern systems (2a).

The increase in safety awareness among the society against danger has caused the public and government to focus more on the human factors such as the "Law of Tort". The professionals are also trying to improve and implies any possible safety requirement to provide the best for their clients or users. So, fire safety engineering is the kind of an example of profession that uses human factors widely in it's
approach. In order to achieve a positive relationship between the occupants, buildings and environment in terms of safety, the human activities, risk, hazard and safety features need to be evaluated or, at least, understood. It will probably assist the implementation of the fire safety engineering procedure that are to be suggested for the educational establishment particularly the residential secondary school.

Another point that shows the needs of having human factors to be considered in fire safety engineering has been long recognised by the 1828 charter of the Institution of Civil Engineers which reported that;

" engineers defined their profession as " the art of directing the great sources of power in nature to the use and convenience of man". (by Julien(2c))

and in Professor Beck's(21) scheme suggested that there tripartite scheme is having the following objectives:-

1. Life safety for occupants of the building of fire origin.
2. Life safety for occupants of adjoining buildings
3. Life safety for fire brigade personnel.

It does shows that the human factors are the main or key element to achieve in fire safety objectives for most buildings. Among the three human factors that commonly used to assess the human safety against fire in terms of individual or personal capability are :-

i. The Human Physical,
ii. The Human Physiological
iii. The Human Psychological

3.4.1 The Human Physical.

It is defined as the human body which is obvious to or cognizable by the senses such as the touch, vision, aural, and other senses like smell, tactile, and taste which can be used to perform a physical movement and activities as a normal human body can do. This matter is involving the ways of human body response towards
the environment physically such as running, walking, crawling, seeing, etc., which
gives a different kind of performance in terms of escaping during emergency. It
also involve the human physical disabilities such as disabled people with limping
legs and or physiological deficiencies such as deafness and the inability to speak.

3.4.2 The Human Physiology

It is more towards size, strength, reactions and adaptability of the physical parts of
human body to the surrounding environment. The definition of the physiological is
the science of the vital phenomena and the organic functions of animals and plants.
The important of these study is to ensure that the design requirements met every
individuals figures and capabilities such as big, small, thin or fat, weak or strong, tall
or short and compare them with the average person.

3.4.3 The Human Psychology

It has been defined as the science of the human mind and soul which involves the
mental and motivational characteristics(28). This area involves the study of human
mind either the occupants being considered to be normal or abnormal such as
mentally retarded or disorder or having other kind of sickness and allergies which
may affect their normal response during emergencies.

3.5 The Usage of Human Characteristics or
Behaviour Study in Fire Safety

In the educational establishment there are several types of occupant. In order to
ensure that all the occupants will be safe during fire emergencies, few or all of the
following characteristics of the occupants suggested by Fire Engineering: CIBSE(7)
need to be considered:-

a/ occupants predominantly familiar with the building and awake (e.g. office,
commercial and industrial premises etc.)
b/ occupant possibly unfamiliar with the building but awake (e.g. shops, exhibitions museums, leisure centres, other assembly buildings)

c/ occupants possibly sleeping but predominantly familiar with the building (e.g. dwellings, hostels)

d/ occupants possibly sleeping and unfamiliar with the building (hotels etc.)

e/ significant number of occupants requiring assistance (e.g. hospitals, nursing homes, disabled or handicapped)

f/ occupants held in custody (e.g. prisons or detention rooms)

Human factors are very important because the life safety is considered to be the main reason for escape design, structural stability and fire resistance requirement, smoke movement design, fire fighting and extinguishers installation and few other fire engineering approaches which are present within the legislation mentioned earlier. It is best that human can react with the fire precautions design and the hardware available within their environment to produce high performance result in reducing the rate of loss and damage. David Canter(23) said that the human aspects of the causes and developments of fire must be understood if its disastrous effects are to be minimized. And also, the cause of damage caused by fires can be traced more to human error than to engineering failure. It is essential that we must learn more about the people who work and deal with the specific environment in a specific building particularly to safe guard human lifes which is the main purpose of fire safety, to reduce the properties damages, to continue the specify mission, to create safer environment and reduce pollutions and also to reduce the loss impact in terms of economy and other damaging effects.

For example, in the design requirements of an escape route will need to consider the followings which contributing towards the required minimum flow time(7):-

a/ Occupant response time which depend on the state of awareness e.g. asleep or awake, drunk or sober, type of occupancy, require clear, prompt and accurate information, the type of warning system and pre-emergency activities undertaken by the occupants including their bodily position such as sitting, lying, standing or moving (7a).

b/ Movement characteristics involve the delay before people start to move or deviations in movement from the optimum escape route, calculations based
on distance to be travelled, the speed of travel and the width of the escape route which are the limiting factor in determining the minimum flow time. However, there are 4 suggested parameters to estimate the minimum flow time:

I. Flow: the number of persons passing a given point in a unit of time (person s\(^{-1}\))
II. Speed: the speed of travel (m s\(^{-1}\))
III. Crowd density: the number of persons occupying a unit of floor area (person m\(^{-2}\))
IV. Escape route width: the width of an opening, corridor or staiway (m).

\[
\text{Flow} = \text{Speed} \times \text{Density} \times \text{Width}
\]

Speed of travel relates to density of crowd; at high crowd densities the ability to walk freely is restricted and hence the speed of travel will be reduced. Other factors to be considered are whether the movement is on a flat surface or ascending, descending, stairways, walking aids, adequate space and accessible number of doors. It was suggested in the Fire Engineering Guide that 1.2 ms\(^{-1}\) can be taken as an average walking speed for design purposes with less than 0.5 person m\(^{-2}\). And when descending stairways the speed is reduced to 1.1 ms\(^{-1}\) giving a vertical component of velocity of the order of 0.75 ms\(^{-1}\). Persons using walking aids require about half the speed of the average person say 0.6 ms\(^{-1}\) for design purposes. At densities of approximately 4 person m\(^{-2}\), movement can become very slow and lead to anxiety and discomfort.

Travel time is the time taken to pass through restrictions such as doorways, which are traditionally designed to accommodate all the occupants in a nominal period of 2½ minutes. This is accepted by the established codes. However, in theory, unless the distance to be travelled exceeds 150 m it is unlikely to have a significant effect on the overall evacuation time, i.e. 150 m can be travelled in about two minutes at a speed of 1.2 ms\(^{-1}\).
e/ Flow through openings is more concerned on the main physical constraint on the time taken to evacuate. Usually the width of doorways openings, corridors and stairs.

f/ Stairway capacity can be physically accommodated at the maximum number of people by an escape stair in a given time (traditionally 2½ minutes) depends on three main factors (7b):
   i/ the width of the storey exits at each level
   ii/ the width of the final exit
   iii/ the number of persons that may be accommodated within the stair enclosure at any one time.

The equation is given in the Fire Engineering Guide: CIBSE page 4-6 to 4-7.

g/ Mechanical movement facilities involved the lifts, escalators and other means of escape particularly to facilitate the disabled like stairlift and wheelchair lifts.

h/ Phased evacuation requires adequate compartmentation to protect those not evacuated immediately which is common practice in high rise buildings. The widths of stairways and their final exits are generally calculated as for doorways openings. To ensure that a phased evacuation may be controlled effectively additional fire protection measures may be required such as a public address system, fire telephones and an automatic detection system.

i/ Evacuation simulation models also assist in the overall escape movement of people through buildings in terms of computer software packages. Features of some of these models include the ability to accept computer-aided design (CAD) generated files for building designs; the evaluation of travel distances; population density calculations; and real time animation of people movement.

j/ Safety margin is generally required to take account of occupant response movement other than direct escape e.g. deviation from the optimum escape route by people unfamiliar with the layout of the building, and uncertainties such as the distribution of people between exits (7c).
References on the horizontal and vertical escape in building can also be found in the Section 3 and 4 of Approved Document B(36). There is also a greater attention needed to research findings on patterns of occupant response pre-movement and movement, exit-choice behaviour and way finding, in evacuation time calculations and all these need to consider the human factors and behaviour. In this way, the fire safety engineering design solutions or installation for a building can be effectively used by the occupants during emergency and increase it's performances to face the fire problems within a building. Besides the human physical, psychological and physiological factors, the activities undertaken by the occupants also need serious consideration. This is to ensure that the building area is used according to it's building functions not vice versa or has it been changed for other purposes than the original plan.

The following Diagram 3.1, is to show that the human factors are considered very important subject in the overall study of producing the evaluation procedure. It does not only acquire the involvement of the human factors in the social science but also in the physical science. In order to assist in the evaluation of fire safety in educational buildings, there are a lot of questions that should and must be asked either about the buildings or occupants, the types of risk available, the hazard that may be confronted and even the presence of the safety requirements within the boundary of the study scope. Four common methods in obtaining the input through questionnaire can be carried out using personal contact, mailing system, telecommunication or telephone and computer.
Diagram 3.1: Human Factors Analysis.

Jonathan Sime(31) also reported in his literature review in the initial stage of the Home Office research programme suggested that a number of common assumptions about escape behaviour should be examined and which are consistent with the physical science and historically with fire safety design regulation and standards were quoted as follows:-

1. People’s safety cannot be guaranteed since, in certain circumstances, they “panic”, leading to inappropriate escape behaviour.
2. Individuals start to move as soon as they hear an alarm.
3. The time taken for people to evacuate a floor is primarily dependent on the time it takes them physically to move to and through an exit.
4. Movement in fires is characterized by the aim of escaping.
5. People are most likely to move towards the exit to which they are nearest.
6. People move independently of one another (unless in a dense crowd).
7. Fire exit signs help to ensure people find a route to safety.
8. People are unlikely to use a smoke-filled escape route.
9. All the people present are equally capable of physically moving to an exit.

**Approach Using 5R:**

<table>
<thead>
<tr>
<th>Design/Regulation/Requirement- Obligation for the designer to design the item so as to eliminate the hazard. (Feasible and affordable way to reduce hazard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Remove Risk - To isolate the people from dangerous interfaces. I.e. Keep the chemical substances in a strong protected area every time after the laboratory work etc. Follow the right conduct or protocol within particular areas such living, kitchen, classroom, sport centre or sleeping accommodations.</td>
</tr>
<tr>
<td>Guard/ Rectify - The hazardous interfaces need to be rechecked and investigated if it still exist within the premises. These include the safety design requirement and risk assessment accuracy.</td>
</tr>
<tr>
<td>Warn / Reminder - The existence of hazardous item which cannot be excluded will have to be provided with warning signs, labels or devices and supervision.</td>
</tr>
<tr>
<td>Train/ Retain - Can be done through training, and increasing the level of skills, knowledge and abilities that are required for fire safety and effective operation and maintenance work of all the equipment and system especially before the occupants are allowed to operate them including level of awareness.</td>
</tr>
</tbody>
</table>

Diagram 3.2: The Evaluation Approach Using 5R Method

Among the 5 key occupancy characteristics that have been investigated are the sleeping risk, numbers, mobility, familiarity and response to a fire alarm. This consideration is taken as the study of occupant level of fire safety awareness which can be referred to Chapter 4. All the information required to produce the evaluation checklist for the educational establishment would need to consider the approach using 5R method. Where it is used to help the professionals in making decision about fire safety and these involved the analysis of the document, established the risk factors, safe guard the potential hazard with safety factors and continuation of assessment, provide the information needed and install the required fire safety system with appropriate operation procedures and the maintenance or retain the safety standard through proper continuous training and increments of fire safety knowledge and level of awareness among the occupants.
John Abrahams (24) said that in terms of occupant's escape, the nature and numbers of the occupants is probably more influential than certain of the physical design factors emphasised in escape code and guidance. He also said that it is the interactions of the communication system with the occupants, the effectiveness of the signposting, the clarity of the internal layout and routes, the quality of fire safety training and response that will minimize the life risk from fire. An understanding of the characteristics of the occupants will suggest their likely speed of travel, and in conjunction with the expected speed of fire spread, enable the architects to design adequate means of escape.

3.6 Hazard, Safety and Risk

a). Hazard

Human factors are important in the process of eliminating the hazard. The designer have to identify the hazard and then try to design the items where it is feasible and affordable so as to eliminate the hazard. The potential hazard within the areas of a building needs to be established in order to know what are the things or occupants at risk and the possible safety systems that could reduce or minimize the hazard to an acceptable standard. Marcelo M. Hirschler (26) pointed out that if a fire does occur, the amount of combustion products generated are other very important aspects of fire hazard. The hazard are classified in terms of source of fuels, source of ignitions and the products of combustions. During the combustion process, certain produced as a result of many complex reaction that are taking and they include heat, flame, smoke and fire gases. Refer to Appendix 3.1 for more information on composition of fire, source of ignition and products of combustion.

b). Safety

Safety is defined as the acceptable level of the danger reduction to zero point or the elimination of hazard by reducing the risk to zero. Human safety measures, property protection provision, the external support from fire brigade and other means of reducing the impact of fire is being considered as fire safety. Its' main
purpose is to create an environment or building for occupants or users which is free from injury, danger and risk of fire. Safety assessment is done to evaluate the available or potential safety measures for the specific buildings to confront the possibilities of fire emergency. It should be able to provide an alternative safe-keeping systems installed at the minimal cost to the proposed buildings or environments but still maintaining the level of safety standard required. The safety systems must be maintained and supervised occasionally to ensure that it is giving the required performance in order to safe guard the occupants and buildings. Professor D.J Rasbash (27) did mentioned that we (fire engineers) are directly concerned here with the safety of people and property from the harmful effects produced by unwanted or uncontrolled fires and explosions which include the action of heat, smoke, toxic products, corrosive products, opressure, blast, projectiles and water that are used to control and extinguish fires.

c). Risk

Overall, the fire risk base case is in terms of property damage, injury or loss of life. The activities, environments, properties and the most important is the human life's that are considered to be at risk in any buildings. Basically, in fire safety evaluation, most but not all risk assessment involving the human lifes. It depends on the fire policy set to achieve by the organisations or building owners. The object at risk need to be managed and controlled in order to reduce the loss. Risk is also measured in terms of vulnerability of the occupants and the objects that are being protected against fire hazard.

For example, the the computer room will have very high hazard from the electrical equipments as the possible source of ignition. The users and the computers will be the one at risk in the case of fire emergency as it effects human lifes, property damage and involving high loss in terms of economy value. So the alternatives to reduce the level of hazard within the space, the items and human lifes at risk should be protected against potential fire by having a good risk management such as limit the operation time of the computer room, provides supervisors during operation time, all the electrical equipments should passed the safety standard set by the Electricity at Work Regulations 1989 or the Institute of Electrical Engineers: Wiring
Regulations (37), escape training or fire drills, detection systems such infra-red or other sensitive smoke detectors, having continuous risk and safety assessment and maintenance of the equipments in used including any other services used for that particular area. Risk management will also contributes the possibility of the occupants escape safely during fire emergencies which may reduce the risk faced by them.

It was reported by Jonathan Sime (33) in his studies on human behaviour in fires that he suggested the following factors should be researched in studying the distance, time and direction of exit choice in escape behaviour:-

1. Advice provided (existing guidance prior to fire)
2. Role in occupancy (e.g. staff or public)
3. Escape route familiarity and building layout.
4. Group dynamics and attachments.
5. Characteristics such as age, infirmity and disability.
6. Location and proximity to exit.
7. Information or communication on fire in progress.
8. Smoke obscuration (visibility, irritancy and toxicity)
9. Fire characteristics (such as heat and smell)
10. Exit signs.
11. Light levels and light sources.

These are essential to be considered in the process of setting up the fire safety evaluation checklist for the evaluator to cover when doing the assessment of the escape route, occupants and other requirements within the propose procedure.

Further discussion on fire risk and fire hazard assessment can be obtained in Chapter 6, along with the introduction of the fire safety evaluation checklist for educational establishment.

3.7 Conclusion

Basically, once the human factors are being considered, they will also consequently catered the need for the building to be designed according to the safety
requirements and based on the calculation and discussion made for that particular building occupancy. Not only life safety but also emphasise the property protection objective which can be achieved with a careful study and consideration of the human factors in designing fire safety requirement in buildings. The fire safety requirements for buildings has been considered in the analysis of the relevant building regulations but the feed back from the building occupants and the human factors being considered in the next chapter 4, which involved the questionnaire on the level of awareness. It is said by Donald S.Tull and Del. I. Hawkins (25) that the information needed from survey research using questionnaires are given on attitudes, feelings, beliefs, past and intended behaviour, knowledge ownership, personal characteristics and other descriptive items which provide evidence of association. But rarely proof “cause”. So the common way to get information on human behaviour during fire for a particular buildings in used is by sending questionnaire to the building occupants. The input from the survey can even be used for the newly design building of a same occupancy and purpose.

The initial fire risk and fire safety assessment has been done through the questionnaires in Chapter 4. This will be followed by Chapter 5 which is very useful for decision making among the professionals and local authorities in terms of fire safety requirements and priorities within the educational establishment particularly the school buildings.

In the fire safety evaluation procedure, it is necessary to consider both the physical requirements of the building and professional judgement who involved in the design of the building. Also important as well to get the feed back and perception from the building occupant who are going to use and occupy the building as long as it exists because the purpose of the building is to create a safe environment for its occupants. It was also stated (32) that the results of the analysis of documents that contain requirements and recommendations could all be included resulting in an interactive framework of risk, loss, cost, safety and requirements.
References:


32. Department of Health and Social Security (DHSS), "Fire Safety Evaluation (Points) Scheme for Patient Areas Within Hospitals", Department of Fire Safety Engineering, University of Edinburgh, June, 1982.


CHAPTER 4: QUESTIONNAIRES: FIRE SAFETY AWARENESS STUDY AMONGST THE OCCUPATIONS OF THE EDUCATIONAL ESTABLISHMENT IN MALAYSIA.

4.0 Introduction

The use of questionnaires is not something new and it is among the few approaches that helps the researcher to get more information on certain subjects. It is a very popular way of getting raw data from the respondents and is used by most sociological and management orientated research work.

Schools, Colleges and Universities are very important establishments in a community. They help to develop the population’s mentality and all other kinds of future development within and outside the community. However, fire accidents within the educational establishment have caused huge amounts of damage in terms of loss of property and particularly human life. Other problems that are associated will be such as the disruption to the continuation of education, the environment internally and externally, the financial impact and also public anxiety.

In order to understand the problems of fire accidents within the educational establishment particularly the boarding schools, a few approaches have been carried out. The first approach was to investigate the occupants’ perception and level of awareness about the importance of fire safety and their level of knowledge plus their ability to react against fire. This matter has been catered for by sending out sets of questionnaires of different levels to selected boarding schools and universities. The involvement of the occupants from within the educational establishment completing questionnaire has allowed the occupants to have the equal right to give their opinions and views about fire safety within their environment. The responses given by them are to assist the fire engineers to develop an evaluation procedure for fire safety engineering and it’s application which takes into account the possible contribution(s) from the occupants of the buildings.
4.1 Purpose

In this particular study, sets of questionnaire have been used to gain the information and data needed, involving the awareness of fire safety of the building occupants in the educational establishment. It is very important to know the level of awareness among the occupants regarding the fire safety before any solution or suggestions can be proposed to upgrade the existing standard of fire safety requirement in the educational buildings.

There are few things that need to be established in order to carry out the evaluation. Among the things to evaluate are the level of fire safety awareness of the building occupants, the level of vulnerability or risk of the buildings, their contents and other objectives, against fire. All of these require some statistical findings to support and strengthen the purpose of carrying out the research. Once the level of fire safety awareness is established then it will be much easier to set the limits for the whole study and to find the way to solve or reduce the impact of the fire in educational establishment buildings, particularly in the schools.

The chosen educational establishment buildings are residential secondary schools and universities. There are no previous studies that really measure the level of fire safety awareness amongst individuals in the third world countries. These studies will help to establish guide lines for research on fire safety to be carried out with a better understanding of the actual facts and problems which exist within the establishments. According to the references in the Building By-law 1982 of Malaysia(14), most of the building and safety requirement are based on the British Standards but are they compatible with the Malaysian environment? Therefore, the questionnaire has been focused to get more information about the occupants knowledge and perception on fire safety and the condition of the existing building so that the standard suggested by the research done in the UK can wisely be accepted as a starting point for other studies. Besides, the trend of fire safety within the educational establishment in Malaysia can be produced for reference when dealing with fire problems within the country.
There are a number of previous research studies on secondary schools occupants response towards fire safety, by other researchers. The findings were more towards human response during fire emergency or the evacuation time in an emergency-related situation which is a vital component for occupant safety. Most of the research undertaken needs to be combined together to form the level of awareness against fire by the pupils in order to overcome the overall fire problems within the establishment. Amongst the areas of concern, fire safety studies were carried out by a number of people. Bryan (1), has tackled the aspect of egress design concept and commented on school fire drills without going into much detail. Sharry (2) considered the general design requirements of educational occupancies and emphasised the fact that younger children require safeguards which are not necessary for more mature occupants. Van Bogaert (3) discussed the physical, mathematical, psychological and practical aspects of school evacuations and Beck (4) emphasised the need to develop a model which would estimate occupant behavioral factors. Mahmut and Dorothy (5) investigated the likelihood of secondary school students responding to fire alarm and cues during fire-related emergency situation. Paulsen (6) traces the developments in the research into human behavior in fire situations but he did not considered age as a variable. Bryan (1) and Canter, Breaux and Sime (8), have developed human behavior models that use three possible situations in a school/classroom environment that take into consideration of action hierarchies involving the arrival or interference of teacher or an adult by instruction and the reception of more cues such as smoke, flames or sirens, and people alerting other people. Other variables such as grade level, gender, previous fire and drill experience were also considered by Mahmut and Dorothy (5). Their findings are important in terms of the response of the building occupants during emergency. However a valuable use of time would be for the management to provide training courses and to create an improvement in the knowledge on fire safety to the level that will assist in minimising the impact of possible loss. One of the best ways to achieve this is by doing a study on the level of fire safety awareness on the building’s occupants.
4.3 Questionnaire for Educational Establishments

The steps taken to measure the level of awareness of occupants about fire safety at secondary school was carried out using questionnaire as the survey method. The questionnaire is set for all the individuals who are involved directly or indirectly in the development and delivery of education such as students, teachers and general workers in the buildings. Officers in the Ministry of Education were approached also. The objective of the questionnaire is to find the level of awareness or understanding of fire safety of people in educational buildings. The subjects of this inquiry include fire risk assessment, the fire safety procedures and the fire technology which exists within the educational premises that can be very useful in reducing the danger of fire.

This questionnaire is presented in two parts: A and B: Appendix 4.0.

I. **Questionnaire A** is addressed to all users, professional people and administrators involved within the educational buildings. The questions asked involve the management of fire safety, the occupants relationship with building and other systems within the educational community and also their awareness of the fire threat.

ii. **Questionnaire B** has been prepared in several versions. Each version is addressed to a specific part of the total population of the educational buildings. The objectives are to gain more information regarding the occupant’s views, activities, knowledge and provision on fire safety aspects given within the educational establishment.

The questionnaire is divided into 7 smaller groupings which are mainly focused on the occupants of the educational establishment in Malaysia. It has been prepared to understand directly the views or level of awareness that each of the groups have on the fire safety in building and their environment. It is very important for any organisation to set up a fire safety policy and to maintain the continuity of their mission.
4.3.1 Occupancy Categories

The 7 levels of occupancy are as follows:-

a). B6 Administrators/ Administration Officers
b). B5b Teachers/ Lecturers/ Tutors
c). B5a Hostel Warden
d). B4 Students Studying in the Universities
e). B3 Students Studying in the Residential Schools
f). B2 Students Living in the Universities Accommodation
g). B1 Students Living in the Hostels of the Residential Schools

As stated earlier, this questionnaire is presented in two parts: A and B. Questionnaire Part A is addressed to all users, professional people and administrators involved with educational buildings. The questions asked were involving the management of fire safety, their relationship with building and other system in the educational community and also their awareness of the fire threat. Questionnaire Part B has been prepared in several versions each addressed to a specific part of the total population of the educational buildings. The objectives are to get more information regarding the occupants views, activities, assigned responsibilities which are directly related with fire
safety, and other aspects of fire risk. Altogether, there are 8 divisions, one in Part A and seven others in Part B and the objectives are as follows:-

**Part A:** Is set for all the individuals who are involved directly or indirectly in the development of education such as the students, teachers and general workers in the educational establishment. The objective is to find the level of understanding of fire safety in educational buildings which require the understanding of fire risk and the procedures and technologies that can be used in educational buildings to reduce the fire hazard. This involves the management of fire safety, relationship within the educational community and awareness of the fire threat.

**Part B1:** Is set for students studying at boarding schools which are fully sponsored by the Government. The objectives are to collect more information regarding the students' level of understanding of the importance of fire safety in their daily lives and activities at the hostel.

**Part B2:** Is set for students studying at local universities who are staying in campus accommodation provided by the university. The objectives are trying to collect more information regarding the level of understanding among the students about the importance of fire safety in their daily life and activities within the university accommodation.

**Part B3:** Is set for students studying at boarding schools sponsored by government. The objectives are to get more information regarding their views, activities, studies and data about the fire safety aspects within the school premises.

**Part B4:** Is set for students studying at local universities or colleges which are fully or partly sponsored by the government. The objectives are to get more information regarding their views, activities, studies and data about the fire safety aspects within the university or college premises.

**Part B5(a):** Is set primarily for the hostel officers, teachers or accommodation officers who are in charge at school and university level. The objectives are to find about the warden or accommodation officer responsibilities, level of understanding
about fire safety, management and also the data regarding aspect of fire safety of the occupants and the hostel buildings.

**Part B5(b):** Is set primarily for the education officers, i.e. teachers or lecturers, who are involved directly with the students and activities at school or at the university level. The objectives of this questionnaire are to gather more information about the education officer responsibilities, their level of understanding about fire safety, management and also the data regarding aspect of fire safety of the occupants and buildings in the educational premises.

**Part 6:** Is set for the heads of departments and administrative officers in schools or universities. The objectives of this questionnaire are to gather information regarding the administrative officer responsibilities, level of awareness concerning the students and physical condition of the school or university buildings in terms of fire safety and hazard, and it will also look at the administrators perceptions about the existing and future development of education.

### 4.3.2 Target Population

The study using the questionnaire was carried out in Malaysia. The target population were the educational establishment occupancy consisting of students, teaching staff, accommodation wardens and administrative officers. It is based on the Full-Residential Secondary Schools system sponsored by the Government and they are the actual level of educational establishment that is taken to be the reference of these studies. Even though, the aim of the studies is basically focused on secondary schools but other contribution from the different level of educational establishment such as the universities occupancy are not being neglected. It is useful to get information from all the occupants of the educational establishment in order to show that the responses are contributing reliable sources of information on fire safety to the whole system. Moreover, the residential secondary schools are mostly built by the government and these are a very good example for all the other educational establishment either managed by private organisation or individual to follow the fire safety requirement and procedure that will be proposed through the findings.
Perhaps, it will also be the first steps for the rest of the educational system to refer to as their own fire safety evaluation procedure.

4.3.3 Selection of Respondents

The list of government residential schools and local universities in Malaysia were obtained from the Malaysian Students Department office in London. There are about 8 universities and over 40 full-residential schools all over Malaysia. Selection of the school's population for this study has been done by selecting either the even or odd numbers from inside a probability hat and then based on that choose the relevant number from the school list, but for the higher education level such as universities and colleges, all 8 are being considered. Only 15 of the full-residential secondary school population was chosen based on odd number from the given list of all the residential school. The list of the population involved can be referred to in the Appendix 4.1. And all of the 15 schools and 8 higher institutions addresses have been reproduced in the Appendix 4.1(a).

4.3.4 Size of the SAMPLE

Since the whole population for educational establishment is huge in number, selection of the target population had to be done for the distribution of the questionnaire. The sample population of the survey were circulated with the questionnaire booklets as follows:-

SECONDARY SCHOOL (15 SELECTED BOARDING SCHOOLS IN MALAYSIA)

B1 (Hostel) Students at School  
(15 x 15) = 225
B3 (Academic) Students at School  
(15 x 15) = 225
B5a Wardens - Living Accommodation  
(3 x 15) = 45
B5b Teachers at School  
(10 x 15) = 150
B6 Administrators (Principal etc.)  
(2 x 15) = 30  
Total = 675
Therefore the total sample of population that has been involved in the studies are 1035 people.

4.4 Preparation of the Questionnaire

A lot of work had to be undertaken to carry out a survey using questionnaire. The difficulties faced include the preparation of the questions but also to ensure that the expected response rate for the return questionnaire can be achieved and that the survey is worth while doing. Other matters that were considered included the target population, size of the sample, time needed for organisation, cost involvement, man power and the statistical analysis programs available.

4.4.1 Categories of Interest

4.4.1.1 PART A Variables

In this study, the following variables have been considered in order to measure the level of fire safety awareness. In each of the questionnaire there are two parts, Part A and Part B. The Part A variable are divided into 5 categories:-

(Refer to Appendix 4.2)

a) Personal Identity - age, gender, level of status within the organisation.

b) Good Observational Skills - years of involvement, building areas, personal safety and workplace.
c) Knowledge and Capabilities of the Occupants on Fire Safety - responsibilities, fire experience, fire fighting, training and attended courses and general knowledge on fire safety.
d) Features of the Workplace - source of ignition, exits and possible fire spread.
e) Ability to Respond to an emergency - actions and decision making during fire emergency.

Part A of the questionnaire is generally measuring the level of awareness of the educational establishment occupancy in terms of responsibility, action taken to fight the fire, training and courses plus knowing their working and living environment. Once the level of fire safety awareness of the pupils or other building occupants within the educational establishment is established and known, the expectation is to ensure that they are successfully evacuated from a building during fire emergency and able to react or response correctly based on the information and training programmes provided. This research is likely to give useful information about human awareness on fire safety without them facing the real danger of fire.

4.4.1.2 PART B Variables

The variables are categorized into the following areas of concern which covered within the Part B of the questionnaire:-

i. Background of the individual
ii. The building areas within the establishment
iii. Awareness of the danger and safety including sense of belonging and regulations availability.
iv. Individual responsibilities and fire safety training courses.
v. Type of risk available and knowledge of fire risk.
vi. Fire safety knowledge.
vii. Buildings and services.
viii. Fire fighting and actions during emergency.
ix. Escape, exit and evacuation.
x. Maintenance
xi. Budget.
Most of the Part B questions has been categorized under the above topics to ease the analysis work. It can be referred to Appendix 4.2.

4.4.2 HYPOTHESIS

There are several hypotheses that have been developed with respect to the fire safety conditions in the Malaysian Educational Establishment.

a. Malaysian students and most education personnel are not well educated in fire safety and not prepared to face fire incidents.

b. In third world countries such as Malaysia, the level of awareness and knowledge about fire safety among its pupils is inferior to the level found in the USA and the UK.

c. The differences in terms of external environment and climatic changes may not require the same fire safety systems to be installed within the buildings as would be required in other parts of the world.

d. Schools built by the government are safe and well managed. It is expected that government schools are supposed to be the example of good building construction which is safe and fulfills the fire safety requirements and other building requirements.

The residential secondary schools (boarding schools) are the main target where all of the occupants within the establishment were involved. However, the higher educational establishments such as the colleges and universities are important also to consider. This is because the occupancy space types within the establishment are more or less the same as the secondary schools. Also, there are spaces that have a slightly higher standard although they have the same purpose as in any other educational establishment. The views from both populations were expected to represent the overall occupancies within the educational establishment and any findings or results should be applicable for the rest of the establishment at all levels.

Other categories of interest were:-

a. Risk and safety assessment

b. Action during fire emergency

c. Building at risk and safety

d. Activities.
4.5 Occupancy Hierarchy Within the Establishment

It is important to know the level of hierarchy within the educational establishment before the survey search can be prepared based on their responsibilities and authority. This assisted in the design of the questions according to the level of occupancy which the questions were asked or directed to. Overall, the whole educational establishment is supervised by the Ministry of Education and consequently followed by the directors of the state education officers, then the local district education officers, headmasters or school principals, teaching staff including general staff and lastly the students.

One has to remember that the existence of the educational establishment is because of the students and the teaching forces.

4.6 Questionnaire Design

An understanding of the subject of fire safety should be obtained in order to proceed with the preparation of the questions. The techniques and methods of answering the questions must also be considered in order to make the process of completing the
questionnaire smooth and easy, for example whether to use multiple choice or open ended questions and many other questions that need to be resolved. Some of the basic questions to be resolved are listed below:-

1. What to ask and what is expected to be achieved?
2. Who is going to be the answer to the questions?
3. How much time is needed for all the questions to be answered?
4. Is the question easy to understand?
5. Would you answer such questions?
6. What form of questionnaire booklet design will the respondents respond to best?
7. Will it be boring and if so how to make it interesting?
8. Will the respondents feel a responsibility to return the questionnaire?
9. How much money will it cost to return the questionnaire?
10. Who will handle the distribution and collection of the questionnaires?
11. How to manage the questionnaire without any direct contact with the respondents?
   i) Convince the head(s) of each organisation involved with the approval letter from the Ministry of Education.
   ii) Convince the respondents the importance of being involved seriously with the project.
   iii) Appeal for assistance and also initiate the heads of the organisations that their advice to the respondents in participating with the survey is very important and the questionnaire needs to be returned.
12. In what form of question will the respondent finds the topics interesting?
13. The latest expected date for distribution and collection of questionnaires.
14. How much will the whole process cost?
15. What do you expect from each of the questions?
16. What analysis package are available and suits with the amount of data?

The above questions can be generalised into several factors which are interrelated one to another. These are:

i. **Preliminary consideration**: information required or needed, sample population and method(s) to collect.
ii. *Question content:* Is it the right question, will it give the required information, is there any distraction for the respondents to answer the questions, does it relate to the objectives and how far in depth do one need to be questioned.

iii. *Question wording:* The words used to ask the questions should be clear and understandable. Try to reduce the uncertainties and confusion to the respondents in giving an answer to a question.

iv. *Response format:* The majority of questions set were multiple choice, dichotomous mostly, but a few open ended questions were also used. This was considered in order to make the process of answering those questions easier and required less time to complete the whole questionnaire book by the respondents.

v. *Question sequence:* Strict sequencing was not used in this survey. This should help the respondents to think freely and as broadly as possible about the subject fire safety. Bias in the given input data by the respondents can be reduced as they were not influenced by the questions' category.

vi. *Physical characteristics:* The use of colour and small size (A5) of the questionnaire was likely to attract more attention from the respondents giving positive participation in answering the questionnaire.

vii. *Pre-test:* A pilot study of the questionnaire is important to be carried out in order to correct any mistakes or to improve anything that is found to be useful in assisting to achieve the purpose and objectives of the survey using questionnaire. The selected group for pilot study was taken from the Malaysian student community in Edinburgh.

Samples of the questionnaire booklets are presented in Appendix 4.0.

4.6.1 Pilot Study

This part of the project was carried out in Edinburgh amongst the Malaysian students studying in Edinburgh. Most of them have had already the knowledge about schools condition and the educational system in Malaysia because of their own educational background and through previous experiences. The changes done to the
questionnaires were only minor matters such as the spelling, arrangement, colours to each of the different categories and most of them could complete the whole questions within 10 --> 20 minutes.

4.6.2 Maximisation of the Response Rate

Several methods have been introduced by researchers on how to arrange questionnaires in order to get enough responses to help with the reliability of the data. About 57% of the respondents made a return and the data collected are considered to be very reliable and robust. Steps that were taken to tackle the respondents are as follows:-

i. Complexity: The questions should be simple and easy to understand.

ii. Data required: Setting up the questions based on the occupants intellectual level.

iii. Authority: Use the influence of the leader or principal to make the respondents feel that it is important to obey or be involved. Engender a feeling that it was their duty to contribute towards fulfilling the objective of the questionnaire. However, the leader's command or instructions will be taken seriously and considered very important to the rest of the occupants.

iv. Time needed: The time needed to complete the questionnaire and time allocated for the distribution, collecting and analysing of the questionnaire. Mail questionnaire normally takes a long time to complete the whole process of distribution and collection of the data. Usually the time constraint should be a little flexible. If the response rate is too slow, a follow up can be done through telephone calls and this showing that the surveyor is serious in doing the survey and the importance of the respondents to contribute towards the studies. It was about 6 months period involved in the distribution and collection of the questionnaire. The details are given below:-
<table>
<thead>
<tr>
<th>Months</th>
<th>Activities Carried Out</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 94</td>
<td>Printing and packaging</td>
</tr>
<tr>
<td>November 94</td>
<td>Posting and early distribution</td>
</tr>
<tr>
<td>December 94</td>
<td>Sample distribution to the respondents</td>
</tr>
<tr>
<td>January 95</td>
<td>1st Collection of the complete or returned questionnaire.</td>
</tr>
<tr>
<td>February 95</td>
<td>Follow up calls to increase the response rate.</td>
</tr>
<tr>
<td>March 95</td>
<td>Final collection of the questionnaire.</td>
</tr>
<tr>
<td>April 95</td>
<td>Setting up the data base and data input.</td>
</tr>
<tr>
<td>July 95</td>
<td>Data Analysis using SPSS.</td>
</tr>
<tr>
<td>September 95</td>
<td>Results.</td>
</tr>
</tbody>
</table>

**v. Instructions:** A proper set of instructions on carrying out and assistance in answering the questionnaire for the officials and respondents must be available particularly to reduce the possibility of confusion. A cover letter, introduction and also purpose of conducting the questionnaire must be enclosed with the main questionnaire. However, the approval and supporting letters from the highest authority of the establishment are very important to be included together with all the mailing packages of questionnaire. It's purpose is to motivate the chosen respondents and to acknowledge their participation in answering the questionnaire is worth while. Refer to Appendix 4.3.

**vi. Sample control:** Even though the questionnaire is sent through mail, it needs to be controlled and one way is to seek assistance from the heads of department or the principals of the schools involved for the survey. A full trust from the respondents representative (head of department or principal) must be built through having a good perception in the first place in receiving a box full of questionnaires. This can be done by enclosing an approval letter from the higher rank authority, in this case the Ministry of Education. Besides, a letter of introduction, purpose and asking for co-operation also has been sent together with the questionnaires. Also refer to Appendix 4.3.

**vii. Survey cost:** It is the worst part of the whole survey. The consideration were depending on the followings:-

a). Target population and sample size. The area to be covered and the required response rate.
b). Survey method either through mail or interviews (printed matter or communication), distribution and collection, man power if required, traveling cost and distance or location.

vii. **Response rate:** The main consideration when survey through questionnaire is being done are the response rate from the returned questionnaire and also the lost rate through mail either during distribution or collection. Another loss rate could also possibly be the refusal to answer certain part of the questions or the whole of the questionnaire.

In order to reduce the loss rate or increase the response rate in the survey using questionnaire, several approaches can be used. These include:-

a). Simplify language and limit the length of questions. (Not too technical or personal)

b). Questionnaire design, size and physical look (colours, etc.) The first impression on the questionnaire book could build up the respondents interest in involving or even to answer the questions. Therefore, different colours has been chosen to represent each level of the education occupancy hierarchy.

c). Suitability of questions for the level of respondents and it's confidentiality.

d). The importance of being involved or selected as one of the respondents.

(i.e.: One person is representing a thousand others)

e). The encouragement and instruction from the leader or head of department or institutions.

f). Preliminary notification by sending a letter of being selected and a good manner in which help or appeal is requested in the covering letter.

g). Follow up telephone calls and flexibility in return deadlines.

h). Letter of Thanks and acknowledgment of their contribution or involvement with the questionnaire.
4.6.3 The Difficulties In Handling Questionnaire

1. *Postage System*- Need someone that can be trusted including the person to contact for distribution and collection purposes.

2. *Budget and Cost*- It definitely costs a lot of money if the questionnaire is developed and produced abroad (distance) particularly in terms of handling cost and printing.

3. *Administration*- Delays were caused by the administrative tasks of approval and allocation of budget. Other tasks that contributed under this headings are as follows:-
   a. *Letter*- Most questionnaires which dealt with such organisations or establishments needed to have an enclosed formal letter (formalities) or even supporting letters.
   b. *Instructions*- normally are best to accompany the questionnaire. This could be the explanation of the purpose or objectives of the questionnaire and ways to deal with any problems occurs. Besides, it could also lead the way how one should do the circulation or distribution and collection of the questionnaire.
   c. *Photocopying and other clerical work*- is also quite important to make sure that the organisation and management of the questionnaire runs smoothly.
   d. *Selecting and acknowledging*- every single person or group of respondents should be acknowledged by letter and a thank you letter if they have succeeded in returning the questionnaires.

Most of the 4.6 section of this chapter is presented in Appendix 4.3.

4.7 Distribution and Collection of Data

Once the questionnaire has been prepared, the next difficult part is to distribute and to collect the questionnaire for the survey. Most of the approach to ease the distribution and collection job has been tackled in the previous topics especially in the preparation of the questionnaire. Moreover, the expected response rate has already being considered to ensure the successful of the survey work. So, steps taken to proceed with the survey work after the preparation of the questionnaire has been done, were:-
a). Approval from the Authority.
   - Ministry of Education
   - State and Local District Education Officers
   - Headmasters or Principals of the school

b). Notification of selected population.

c). Appeal for permission and co-operation to carry out the survey without being present within the establishment.

d). Questionnaire distributions and time limitation.

Each institution has their own leader or head of department who has been very cooperative in the process of distributing and collecting those questionnaire books. This was done by giving a proper proof which were enclosed together with the questionnaire. The head of department then decided on how critical the issues is and with his/her authorization were used to give the orders to the rest of the teachers and students to make the contributions. These has made the whole process a lot more easier.

4.7.1 Approval from The Local Authority

In Malaysia, the bureaucracy in it's administrative work should be properly approached so that the process of distributing and collecting plus entering the educational establishment compound may not be misunderstood. Several administrative hierarchy has to be approached in order to carried out the questionnaire. The hierarchy are as follows:-

i. Ministry of Education - First approval stage to be carried out. Without the letter of approval by the Ministry of Education officer in charge of the schools and universities, no questionnaire project can be proceed within that boundary. So the first thing to be obtained is the letter of approval from the Ministry of Education. A special request form is provided to be completed by the researcher and returned. (Refer to Appendix 4.3: Approval Letter from the Ministry of Education and the Form to carry out the survey search)
ii. **Head of Department / Headmaster or Schools Principal / Deputy Chancellor.**

Second stage is to ask the permission to carry on the project within the schools or universities boundary. Every individual head of the organisation/ schools or chancellor have to be approached individually by enclosed a formal letter requesting for permission and co-operation together with the purpose of the research, the approval letter from the Ministry of Education and of course the background of the researcher.

iii. **Sponsorships** - The third stage is the sponsorship body that pays for the research to be carried out. The sponsorship body is the Public Services Department of Malaysia. An approval letter from the Ministry of Education was needed to make sure that the budget allocated is being used for research purposes.

### 4.7.2 Administrative Work

In dealing with the questionnaire, the author has also considered the administrative work that involved the preparation of the covering letters, printing, cost and other supporting evidence that shows the importance and interest of the questionnaire to be set at the first place and to assist the flow of the whole survey work. Preparations involving in the administrative work were as follows:-

a. Formal letter requesting for an approval and permission to carry out the survey within the educational establishment from the Ministry of Education.

b. Formal letter of preliminary notification, requesting for assistance and purpose of survey to every selected schools and universities.

c. Formal letter to the representative in Malaysia in receiving the whole load of questionnaire before further distribution work can be done. The required covering letter and packaging have to be done from the UK before they being distributed locally by the representative. This assists in ensuring that the proper package will be sent to the right respondents or population. Normally the representatives are the one who we believed, can be trusted and reliable. Therefore incentive is not needed but probably just the cost of stamps for postage will be required.

d. Purpose of conducting the survey, research and surveyor identity is considered to be quite important for convincing the schools and universities...
authorities about the questionnaire survey. Usually an appeal letter will be enclosed to please the authority co-operation in carrying out the survey using the questionnaire.

e. Instruction or suggestions of ways to approach and methods to proceed with the distribution and collection of the questionnaire to the population can also be given in written or else just based on trust that the administrative officers are capable to decide the best way to distribute and later to collect the complete questionnaire from the respondents. Educational establishment can easily conduct the survey as explained in the previous topics.

f. Once the survey questionnaire has been returned and collected, a thank you and appraisal letter has been sent as the final follow up to each leader or principal of the schools or universities.

The data or questionnaire booklets collected from the survey were summarized as follows:-

<table>
<thead>
<tr>
<th>TYPE OF BOOK</th>
<th>RECEIVED</th>
<th>TOTAL DISTRIBUTED</th>
<th>PERCENTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>152</td>
<td>225</td>
<td>67.55 %</td>
</tr>
<tr>
<td>B2</td>
<td>53</td>
<td>120</td>
<td>44.17 %</td>
</tr>
<tr>
<td>B3</td>
<td>155</td>
<td>225</td>
<td>68.89 %</td>
</tr>
<tr>
<td>B4</td>
<td>58</td>
<td>120</td>
<td>48.33 %</td>
</tr>
<tr>
<td>B5a</td>
<td>25</td>
<td>69</td>
<td>36.23 %</td>
</tr>
<tr>
<td>B5b</td>
<td>102</td>
<td>230</td>
<td>44.35 %</td>
</tr>
<tr>
<td>B6</td>
<td>33</td>
<td>46</td>
<td>71.74 %</td>
</tr>
</tbody>
</table>

OVERALL       578      1035               55.84 %

The exercise of the survey method can be considered successful with overall responses of 55.84%. The average responses of the students from residential secondary schools is 68.22 % and 46.25 % from the students at the universities. The average is compared to the total number of questionnaire books sent out to the particular group involved.
4.8 Data Analysis

The returned questionnaire are then being analysed in order to see the results of the survey undertaken. However, before the analysis work can be done, the preparation of the data base and data input will have to take place.

4.8.1 Choosing the Statistical Analysis Package

The preparation of the data base has been undertaken using a statistical analysis package called the SPSS for Windows Release 6.0 software on mainframe computers. SPSS is a comprehensive and flexible statistical analysis and data management system. It also provides a user interface that makes statistical analysis more accessible for the casual user and more convenient for the experienced user. SPSS also can take data from almost any type of file and use them to generate tabulated reports, charts and plots of distributions and trends, descriptive statistics, and complex statistical analyses(12).

4.8.2 Preparation of the Data Base

The data received through the questionnaire are then keyed or stored in the input windows of the SPSS using the Data Editor window. The data Editor window opens automatically when starting the SPSS session and displays the contents of the data file. New data files can be created with the Data Editor as it provides a user interface. Most of the data has been analysed in terms of percentages, means, correlation, descriptive, crosstabs and multi response. Most of the analysis work was done using the dialog box and statistical menu selection in the SPSS for Windows 6.0.

4.9 Results

The feed back given by the respondent within the questionnaire are divided into two part, part A and part B. As the author has mentioned earlier that the analysis will be started with part A followed by part B.
4.9.1 Part A: Questionnaire

Questionnaire Part A is addressed to all users, professional people and administrators involved with educational buildings. The subjects of this inquiry include the understanding of fire risk, and those procedures and technologies that can be used in educational buildings to reduce the fire hazard. It also involves the management of fire safety, relationship with other people in the educational community and awareness of the fire threat. The related questions' number from the questionnaire is written on each of the following paragraph which explained the findings. (Refer to the Appendix 4.4 (a) and (b))

4.9.1.1a Individual Background

Q:1/. There were 578 respondents involved in this Part A of the questionnaire. The highest contribution is the students studying at the boarding schools. 26.0 % of the total respondent are from B1 (Students Living in the Hostel) and 27.0 % from B3 (Students Studying in The Boarding School).

Out of 578 respondents, about 28.4 % are 16 years of age and 16.0% are 17 years old. The range of respondent is from 15 years to 54 years old. At school level, the age seems to be adequate to set up a training program and easier to educate the students with fire safety knowledge. There are about 58.3 % male respondents and 41.7 % female. It does shows that the questionnaire are equally distributed amongst the gender of the population.

4.9.1.1b Responsibility Within the Area of Concern

Q:2/. The type of organization involved are mainly from boarding schools 74.0 % and universities 26.0 %. The occupancy are consist of students, teachers headmasters or principals, Head of department, accommodation officers, wardens, lecturers, administrative officers and general workers plus security staffs. In the table “Group Post” (Refer to Appendix 4.4 (b) ), it shows that the total responses are 601 which are more than the actual number of respondent (578). This is because some of
the respondent could hold more than a post within the educational establishment in the same time. For example, a lecturer could also hold the position as a warden within the university accommodation and it is the same case for a teacher at school where he or she can also be responsible as the warden for the hostel buildings.

Q:3/. Generally there are about 72.0 % of respondents represented by students and only 19.1% by teachers. The rest of the respondents percentages are represented by Lecturers, Head of Departments, Wardens, Headmasters or Principals and Researchers.

Since the educational establishment is built with these 2 main occupants (students and teachers) so it is important that the questionnaire set will serve it's purpose(s).

<table>
<thead>
<tr>
<th>Occupant</th>
<th>Number</th>
<th>Risk</th>
<th>Loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>Greater number</td>
<td>Greater risk exposures</td>
<td>Greater loss</td>
</tr>
<tr>
<td>Teachers</td>
<td>Greater number</td>
<td>Greater risk</td>
<td></td>
</tr>
<tr>
<td>Headmaster</td>
<td>Small number</td>
<td>Low risk</td>
<td></td>
</tr>
</tbody>
</table>

In a survey using a questionnaire, the overall response from the occupants within the educational establishment (School and University) has generated a very good response rate (55.84 %). This is very important in order to achieve a representative set of views about the occupants awareness and perceptions on Fire Safety. And the purpose to set up an evaluation procedure based from these outcome will be more acceptable by all groups.

Q:4/. The duration of the occupants involvement within the educational establishment are in the range of 1 to 55 months (more or less up to 12 years). The graph shows that the highest percentage of respondents involvement within the educational establishment is between 1 month to half a year (6 months). This indicated that the respondents level of awareness about their safety and the buildings condition around them are only based upon the duration of 1 to 6 months. There is time taken by occupants for familiarizing and adjusting to the environment which will helps in certain ways, such as:-

a. Decision on the right time to set up a fire safety training courses within the educational establishment. Will it be a good decision to have an early session
on fire safety training or fire drill during the early stage of pupils registration or later?

b. Comparison between those who have had 5 years of experience being in the premises with the group of people who have just be there for a couple of months. Do they really know where to go and what to do during any emergency?

Normally the longer time spent in the organisation the better understanding of the organisation structure in terms of administration, job allocation, space distribution and services or maintenance available by the building occupants. Therefore, any information, fire drills and training on fire safety should be conducted within the earliest time possible within the first six months of the year.

So, this was based on single batch method, which Jim Ure (5), did consider for the single batch method of survey is less accurate than using daily symptom dairy. This is because occupants are not having to rely on medium and long term memory when answering the questions. It was agreed but only to certain extent where the questions were dealt only with short term personal symptoms monitoring. It was suggested that the daily symptom dairy method would produced more accurate and reliable results if the survey is carried for the same duration as the time spend by occupants within the premises starting from the beginning till the expected date that a single batch method would like to consider in any survey studies.

However, Jim Ure (5) also said that, daily symptom dairy will mostly applicable for systems that are in demand continuously i.e.: the supply of hot water to wash hand basin. However, the single batch method could be more relevant for the rare event such as fire and not for maintenance of system. The effect imposed by fire to any individual would definitely be the only one unpredictable time and may caused fatal. Whereas other symptom such as hearing and lighting comfort would probably effects individuals in a long period of time which could be temporary or permanent depending on the improvement or changes made to the environment (lighting fittings, natural lighting, thicker walls, double glazing, ear-phone, reducing the noise of the machine by applying lubrication oil, etc.).
4.9.1.1c Awareness and Responsibility

Q:5/ The respondents seems to be spending most of their time in the classroom or lecture hall particularly for the educational part of the buildings. Other areas which is common for the students are the hostel or accommodation, library and laboratory. The teaching staffs are normally based in the staffroom particularly in school or individual office for the lecturer at the university level. The areas within the educational establishment are arranged according to their priority as follows:-

Table 4.9.1.1c (5)

<table>
<thead>
<tr>
<th>Building Area</th>
<th>Percentage %</th>
<th>Fire Safety Objective within Educational Establishment and it's priority.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>33.5</td>
<td>Life / Mission / Property</td>
</tr>
<tr>
<td>Hostel</td>
<td>21.0</td>
<td>Life / Property</td>
</tr>
<tr>
<td>Library</td>
<td>12.4</td>
<td>Property / Cost - books, references, equipment</td>
</tr>
<tr>
<td>Laboratory</td>
<td>10.3</td>
<td>Property / Environment or high hazard</td>
</tr>
<tr>
<td>Staffroom</td>
<td>6.5</td>
<td>Life / Mission or teaching references</td>
</tr>
<tr>
<td>Computer</td>
<td>3.9</td>
<td>Property / Cost or electrical items</td>
</tr>
<tr>
<td>General office</td>
<td>3.4</td>
<td>Property / Mission - records</td>
</tr>
<tr>
<td>Individual office</td>
<td>2.8</td>
<td>Property or teaching or learning references</td>
</tr>
<tr>
<td>Studio</td>
<td>2.4</td>
<td>Property or combustible materials</td>
</tr>
<tr>
<td>Other</td>
<td>2.2</td>
<td></td>
</tr>
<tr>
<td>Workshop</td>
<td>1.1</td>
<td>Property or High hazard area</td>
</tr>
<tr>
<td>Kitchen</td>
<td>0.6</td>
<td>Property or electrical and source of ignition</td>
</tr>
</tbody>
</table>

Q:6/ In the survey also shows that 84.0% of the respondent do think about their personal safety and fire hazard. However, 16.0% of the respondents still seems to be ignorant or seldom think about their safety and fire hazard within the environment. This output is very important proof that precaution steps such as education and training on fire safety is still needed to ensure that every individual is safe and capable to escape during an emergency.

Q:7/ Most of the occupants of the educational establishment do concern about their safety particularly against fire at their workplace. 80.0% of the respondents rank their concern about fire safety at workplace above moderate level which is level 3 (Referred to Appendix 4.4(b): Part A). However, 20.0% more are still careless about their safety probably because they are still new or may be their work or job did not deals with anything dangerous according to their own perceptions.
Q:8/. The responsibilities for Fire Safety by occupants are arranged as follow:-

<table>
<thead>
<tr>
<th>Responsibilities</th>
<th>Priority rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Checking occupants safety</td>
<td>1</td>
</tr>
<tr>
<td>Set Policy on Safety within specific area</td>
<td>2</td>
</tr>
<tr>
<td>Maintaining the Fire safety system</td>
<td>3</td>
</tr>
<tr>
<td>Member of the Fire Brigade Society</td>
<td>4</td>
</tr>
<tr>
<td>Organizing Fire safety Seminars</td>
<td>5</td>
</tr>
<tr>
<td>Supervise Fire safety courses/ drill</td>
<td>6</td>
</tr>
<tr>
<td>Fire safety cadet officer</td>
<td>7</td>
</tr>
<tr>
<td>Head of Safety Department</td>
<td>8</td>
</tr>
</tbody>
</table>

The rank order are arranged according to the number of respondent involvement. This answers may be the source of information that some of the occupants might have on fire safety in order to ensure that the place are always kept safe against any threat particularly in this case the fire threat. The responsibilities are amongst the possible ways to encourage the occupants to be active and upgrade the level of awareness and concerned about fire safety within their own premises. It is hoped that those occupants with the following experiences will be very helpful in any emergency fire cases. In schools, checking is normally done by the wardens or teachers. However, the types of responsibilities does shows that the occupants, particularly the administrators, do ensure that the premises are safely observed and guarded against fire hazards.

Q:9/. There are 88.0% of respondent has not yet involved or experienced with fire accident and only 12.0% did have an experience with fire. This may be the reason why nearly 20.0% of the respondents did not care or had a low concern about their safety within the establishment (refer to Q:7) particularly at their workplace. It is important to increase their awareness on fire safety so that there will be reduction in terms of fire accidents causes by human error. Preparation and fire safety training should be conducted for all the occupants in order to expose them with some ideas on how to handle a fire emergency.

Q:17/. The natural ways for the occupants being educated about the exit and escape route around their environment within the educational establishment is as follows:-

<table>
<thead>
<tr>
<th>Observation</th>
<th>50.4%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Training</td>
<td>44.9%</td>
</tr>
<tr>
<td>Others</td>
<td>4.6%</td>
</tr>
</tbody>
</table>
Even though the occupants managed to know their escape route and nearest exit through observation but with a proper training and education (theories) will probably have in a higher chance of survival during emergencies.

4.9.1.1d Types of Risk

Q:10/. The sources of ignition which are commonly found in the educational establishment such as schools and universities are as follows:-

<table>
<thead>
<tr>
<th>Source(s) of Ignition</th>
<th>Percentage %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/ Carelessness</td>
<td>38.4</td>
</tr>
<tr>
<td>2/ Electrical Appliances</td>
<td>25.6</td>
</tr>
<tr>
<td>3/ Not known</td>
<td>12.8</td>
</tr>
<tr>
<td>4/ Arson</td>
<td>9.3</td>
</tr>
<tr>
<td>5/ Smoking habit</td>
<td>5.8</td>
</tr>
<tr>
<td>6/ Natural Disasters</td>
<td>5.8</td>
</tr>
<tr>
<td>7/ Other specify</td>
<td>2.3</td>
</tr>
</tbody>
</table>

The table above represents occupants views about normal source(s) of ignition that is possible to happen or based on fire accidents which had occured in that premises. The outcome can be considered small compared to the number of respondents involved with the project. 12.8% of the occupants who has been involved with fire accidents seems to be ignorant about the source(s) of ignition. This shows that some of the building occupants need to be reminded or make to be aware of the danger around their work places or surroundings. It probably will help them to set up a precaution action(s) in the case of fire emergency.

However, carelessness still the major source of ignition in most fire cases either being left without any back up observation on the activities and appliances or totally forgotten or ignorant about the possibilities that one acts and appliances in use may cause fire disaster. Therefore the major issue that most educational establishment or similar building function need to improve is the level of awareness amongst the occupants before considering other fire safety requirements.

The electrical appliances give very high percentages in terms of contribution to the source of ignition in many cases of fire accidents in most buildings, particularly within
the educational establishment. Serious considerations about electrical appliances must be given by the administrators or the building owner.

It was reported by the Royal Safety Commission for Schools in Malaysia (13) that schools in general have electrical problems such as:-

a. Switches, electrical appliances and lamps which are of low quality. Can cause short-circuits.
b. Cable need replacement.
c. Rats and ceiling maintenance.
d. Over loaded on electric-cable for over-crowded connection.
e. Using portable water heater.
f. Using the switch room as a storage area.
g. Switch room doesn't have any fire extinguisher.

Q:15/. And the reasons for not being able to control or suppress the fire are given as follows:-

Table 4.9.1.1d (15)

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Percentages %</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Did not know the causes for the fire to grow or spread</td>
<td>42.0%</td>
</tr>
<tr>
<td>b. The fire grew very rapidly before any other action can be taken by individual</td>
<td>23.2%</td>
</tr>
<tr>
<td>c. Did not managed to get to the source of the ignition</td>
<td>11.6%</td>
</tr>
<tr>
<td>d. The respondents can hardly see a thing as it was distracted by thick smoke</td>
<td>10.1%</td>
</tr>
<tr>
<td>e. The respondents who tried to suppress the fire did use a wrong type of fire extinguisher</td>
<td>7.2%</td>
</tr>
</tbody>
</table>

The outcome of the question seems to tell us that the occupants really do need to be more aware of what exactly fire hazards that may exist within their premises, some training on fire drill and knowledge of the fire safety and hazards will need to be carried out in order to prepare the occupants with any future accident.
Q:11/. Out of the 12.0% of the respondents who had an experience with fire, only 37.8% did make an effort to put out the fire and 62.8% probably just escaped and leave it for the emergency team to deal with the fire. Q:9 and Q:11 of these questionnaire seem to prove that only a very small number of individuals who dare and know exactly how to deal with fire in an emergency case.

Q:16/. Most of the respondents do know their way out or the exit route and doors from their workplace in case of fire emergency, it is 92.6%. This point may be very useful to show how the occupants will react towards the exit route available to escape during fire drill or real fire. It will also help to know exactly how long for them to evacuate an area. How did they familiarized with the environment? The answer is given in the next question.

Q:24/. The sources of Fire Safety Knowledge given by the educational establishment through the questionnaire are as follows:

<table>
<thead>
<tr>
<th>Sources of fire safety knowledge</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>General reading</td>
<td>34.6%</td>
</tr>
<tr>
<td>Mass media and friends</td>
<td>17.7%</td>
</tr>
<tr>
<td>Notices and sign system</td>
<td>11.8%</td>
</tr>
<tr>
<td>Rules and regulations</td>
<td>9.9%</td>
</tr>
<tr>
<td>Subjects taught in schools or colleges</td>
<td>8.1%</td>
</tr>
<tr>
<td>Extra Co-curriculum activities</td>
<td>7.1%</td>
</tr>
<tr>
<td>Assigned Responsibility</td>
<td>4.8%</td>
</tr>
<tr>
<td>Past Fire Accident(s)</td>
<td>3.1%</td>
</tr>
<tr>
<td>Other</td>
<td>1.5%</td>
</tr>
<tr>
<td>Profession</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

4.9.1.1f Fire Fighting And Actions

Q:12/. Among the fire fighting equipment that were used by the occupants to fight fire are:

<table>
<thead>
<tr>
<th>Fire Fighting System</th>
<th>Percentages %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portable extinguisher</td>
<td>29.4</td>
</tr>
<tr>
<td>Fire Blanket</td>
<td>10.1</td>
</tr>
<tr>
<td>Water</td>
<td>45.9</td>
</tr>
<tr>
<td>Sand</td>
<td>9.2</td>
</tr>
<tr>
<td>Other</td>
<td>5.5</td>
</tr>
</tbody>
</table>
Water and portable extinguisher are the common sources of fire fighting equipment. It could be of gaseous, water and foam agents. The water may be found in the bucket system or the portable extinguisher system. Whereas fire blanket and sand were probably used by occupants within the laboratories and kitchen areas. Other fire fighting equipment used within schools were hose reels and dry and wet risers.

Q:13/. The respondents or occupants were not be able to react against the fire within the educational establishment during emergency because of several reasons:

<table>
<thead>
<tr>
<th>Descriptions</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. They were not allowed to approach the fire.</td>
<td>52.1%</td>
</tr>
<tr>
<td>b. It will be handled by a special assigned personnel</td>
<td>19.3%</td>
</tr>
<tr>
<td>c. They did know how to deal with the fire accident.</td>
<td>12.6%</td>
</tr>
<tr>
<td>d. There is no fire fighting equipment available</td>
<td>10.9%</td>
</tr>
<tr>
<td>e. The label on the fire extinguishing system are not clear</td>
<td>5.0%</td>
</tr>
</tbody>
</table>

It does indicate that some work or suggestion to improve the fire safety management and maintenance work on the fire safety equipment need to be done generally to upgrade the fire safety services and signs within the educational establishment.

Q:14/. The actions taken to fight against the fire seem to give various results, 66.9% of the suppression effort to control the fire from spreading were successful but still 33.1% were unsuccessful.

Q:18/. The respondents agreed that the following actions would probably be taken by most occupants of a building during notification of smoke in a room:

<table>
<thead>
<tr>
<th>Actions</th>
<th>Percentages</th>
<th>Rank order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Warn Others</td>
<td>20.6</td>
<td>1</td>
</tr>
<tr>
<td>Inform the security</td>
<td>18.5</td>
<td>2</td>
</tr>
<tr>
<td>Get help from anybody</td>
<td>17.6</td>
<td>3</td>
</tr>
<tr>
<td>Call 999 and Fire Brigade</td>
<td>17.0</td>
<td>4</td>
</tr>
<tr>
<td>Break the alarm glass</td>
<td>16.7</td>
<td>5</td>
</tr>
<tr>
<td>Run away, saving own life</td>
<td>7.3</td>
<td>6</td>
</tr>
<tr>
<td>Not sure what to do</td>
<td>1.2</td>
<td>7</td>
</tr>
<tr>
<td>Other, specify</td>
<td>1.0</td>
<td>8</td>
</tr>
</tbody>
</table>
The above table does give us a steps to follow in case of emergency. Those are the steps taken from the overall responses given by the building occupants using the "true" or "false" statements. However, the degree of the accidents may differ from one another and the agreement from the given answers of the occupants may well be referred to as the norm actions taken by most of the building occupants within the educational buildings during notification of fire smoke in a room.

Q:19. This question shows the ranking order of the occupant’s actions during fire emergency based on the percentage of responses are as follows:-

<table>
<thead>
<tr>
<th>Actions</th>
<th>Sequence Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Try to find the smoke source</td>
<td>1st (11.0%)</td>
</tr>
<tr>
<td>Open up all the window and doors</td>
<td>2nd (10.7%)</td>
</tr>
<tr>
<td>Try to extinguish the fire according to own capability</td>
<td>3rd (10.5%)</td>
</tr>
<tr>
<td>Look for any fire extinguisher</td>
<td>4th (10.4%)</td>
</tr>
<tr>
<td>Shout for help and inform others or the representative</td>
<td>5th (10.3%)</td>
</tr>
<tr>
<td>Evacuate or run out of the building with belongings</td>
<td>6th (10.0%)</td>
</tr>
<tr>
<td>Break the emergency alarm glass</td>
<td>7th (9.6%)</td>
</tr>
<tr>
<td>Call the Fire Brigade or &quot;999&quot;</td>
<td>8th (9.4%)</td>
</tr>
<tr>
<td>Ensure the place is under control until the arrival of police etc.</td>
<td>9th (9.3%)</td>
</tr>
<tr>
<td>Give the details of the accidents to the authority if required</td>
<td>10th (8.8%)</td>
</tr>
</tbody>
</table>

Occupants normally give a look at the fire problems and if they think to their own capability that the situation should be safe and can be managed by themselves, only then they will look for the extinguisher system. If not, they probably will shout or inform others and evacuate of the building. However, the second sequence seems to be a wrong thing to do "open the windows and doors" but the reason for doing that is may be to get rid off the smoke in the case of smoldering fire so that the individual will have a better look at the source of ignition and to tackle the problems with extinguishers. And also, to make the workplace clear of smoke and easy to breath air. In Malaysia context, normally the workplace are provided with ceiling fan which causes the smoke to be spread out all over the room. This will cause distraction to the occupants and to allow the cold air from outside or external to cool down the temperature within the room to avoid further damages caused by heat.

Sometimes, buildings in Malaysia will normally be a building that have a high degree of leakage particularly the educational buildings. This is done to ensure that fresh air is well circulated within the area. Therefore, an adequate knowledge on fire and
smoke need to be disseminated to all the occupants so that they will know whether to close or to open the windows and doors. This problems will be tackled with the experimental research work. These will return later in the studies.

4.9.1.1g Training

Q:20/. About 66.1 % of the respondents had been on the fire safety training course(s) but there was also about 33.9 % did not yet have the chance undergoing any fire safety training.

Q:21/. Out of the 66.1 % respondents who had gone for the fire safety training, only 53.6 % satisfied with the course or training organized. 46.4 % of the respondents who had undergone the training were not satisfied with the fire safety training and courses organized. This facts is important for the organizer and administrators of the fire safety courses to realize that the need for some changes in organizing the training and courses will probably help to reduce the rate of fire accidents if only people are interested in the first place.

Q:22/. The reasons for attending such courses were given by the occupants:-

Table 4.9.1.1g (22)

<table>
<thead>
<tr>
<th>Reasons for Attending the Fire Safety Course</th>
<th>Percentages %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compulsory</td>
<td>37.9 %</td>
</tr>
<tr>
<td>For General Knowledge</td>
<td>22.8 %</td>
</tr>
<tr>
<td>Assigned Responsibility</td>
<td>15.8 %</td>
</tr>
<tr>
<td>Apart of the Co-curriculum</td>
<td>12.0 %</td>
</tr>
<tr>
<td>Voluntarily</td>
<td>9.4 %</td>
</tr>
<tr>
<td>Apart of the subject or course</td>
<td>1.3 %</td>
</tr>
</tbody>
</table>

So the result does shows that about 40.0% of the respondents did attending those fire safety training or courses as a compulsory agenda and this probably the cause for not being satisfied with the course. The question why they were not satisfied will need to be examined by looking at their relationship between the Q: 20, Q: 21 and Q: 22.
Q:23/. Fire safety training courses have been arranged by the following organizations:-

<table>
<thead>
<tr>
<th>Organizer</th>
<th>Percentage of responses</th>
</tr>
</thead>
<tbody>
<tr>
<td>School</td>
<td>44.6 %</td>
</tr>
<tr>
<td>Fire Brigade Department</td>
<td>25.4 %</td>
</tr>
<tr>
<td>University</td>
<td>11.1 %</td>
</tr>
<tr>
<td>Joint Fire Brigade with the host</td>
<td>9.4 %</td>
</tr>
<tr>
<td>Other</td>
<td>2.4 %</td>
</tr>
<tr>
<td>Ministry of Education</td>
<td>2.2 %</td>
</tr>
<tr>
<td>PIBG (Parents and Teachers) Society</td>
<td>2.2 %</td>
</tr>
<tr>
<td>Department</td>
<td>1.5 %</td>
</tr>
<tr>
<td>Private Bodies</td>
<td>1.0 %</td>
</tr>
</tbody>
</table>

Note: The number stated on the left hand side of each paragraph referred to the number of the questions asked in Part A of the questionnaire.

4.9.2 PART A: Questionnaire - Open Ended Question (A25)
(Refer to Appendix 4.5: Part A: Excel)

4.9.2.1 Q:25 : B1

Sixteen respondents of the B1 group suggested that the fire safety awareness can be improved by organising more frequent lectures, seminars and training courses including practical and theoretical knowledge to the students. Other suggestions included arranging more fire drills, mount a campaign on fire through mass media and organise fire training courses as part of the students curriculum activities. Students must not only receive theoretical knowledge on fighting the fire but also should be trained to fight fire. Fire drills should be done with the help and supervision of experts such as the fire brigade or other fire officers. Other comments involved upgrade the fire fighting equipment within the school and ensured that the installed fire safety system is kept working. However, there is also a suggestion about the installation of detection systems. The applicability of the installation of such system will need to be appraised carefully.
There are some comments by the respondents of the B2 questionnaire group where it was noted that it is very important to increase individual level of awareness. The effort in providing more information and creating awareness to every individual can be disseminated through the following suggestions:-

a) Organise Fire drills and Fire Safety Training Courses frequently.

b) Formation of Safety Committee and assignment of responsibility to individuals.

c) Mass media giving information about fire hazard, safety and risk including ways or methods to tackle fire emergencies.

d) Organising more lectures, seminars, exhibitions, demonstrations and campaigns on the importance of fire safety awareness for all levels starting from primary school until the university stage.

The administrators should also be aware that the participation from every individuals is very important for the fire safety courses and training which are being organised within the education establishment, should not only involved the students but also the staffs or teachers. The above are the comments which has been suggested by the respondents of the B2 group of questionnaire.

Seventeen respondents (B3) considered that more information and additional training for fire emergencies was the best way to upgrade awareness of fire safety. Positive suggestions included quizzes and formation of a society for Fire Brigade Cadets. These responses are from the school students themselves and show a real concern for the life safety problems in the buildings. Other B3 respondents included the need to upgrade facilities for first aid fire fighting equipment.

From the group of student respondents from universities (B4) where 13 out of 15 comments were for the improvement of information, knowledge and training through
attendance at courses and fire safety training sessions. Other positive comments echoed these from the B3 respondents. These included the setting up of a college fire brigade (such a fire department exists at Gordonstone School in Scotland and at University of Maryland, USA) and the formation of a Fire Safety Club.

4.9.2.5 Q:25 : B5(a)

Although only two B5(a) respondents gave comments, both considered that the subject "fire safety" should be a compulsory part of the school or college curriculum for all students.

4.9.2.6 Q:25 : B5(b)

The teachers and lecturers B5(b) commented strongly that more information should be given to the lecturer or teacher. The methods of information transfer were varied and included: compulsory lectures, video and television, demonstrations of fire fighting and fire drills. All were positive responses and supplementary to these from the students. However, there was a hint that the regulations exist require fire safety education to be carried out and fire drills to be arranged and a proper discharge of responsibilities is all that is needed.

4.9.2.7 Q:25 : B6

The responses from the "responsible persons" or the administrators (B6) tend to confirm that more fire safety education is needed and perhaps the best source of the education is the fire brigade.

In summary for the open-ended questions, a high proportion of respondents to Q:A25 agreed that more fire safety education is needed in the Malaysian Educational system. The teaching could be done by the fire brigade and by any medium such as talks, lectures, video, television or visits. Ideas such as Fire Cadet Societies are positive
and a general agreement about the need for fire drills to be conducted is clear from the responses.

4.9.3 **Part B : Questionnaire** (Refer to Appendix 4.6)

This part of the questionnaire has not been covered in total as it is not necessary for it to be used for the whole studies. However, the output of the questionnaire may also be used in any future studies particularly to analyse the human behaviour and reactions with regards to human and fire. It could be very usefull data for the social sciences and physical sciences to analyse in depth about human behaviour involving fire safety and other related fields to come with better solutions for the problems exist within the human habitat and surroundings.

4.9.3.1 **Q: 30(B6)**

<table>
<thead>
<tr>
<th>AREA</th>
<th>Electricity</th>
<th>Gases</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>78</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Staff room</td>
<td>78</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Canteen</td>
<td>46</td>
<td>52</td>
<td>5</td>
</tr>
<tr>
<td>Laboratory/ workshop</td>
<td>64</td>
<td>66</td>
<td>70</td>
</tr>
<tr>
<td>Library/ Resource Centre</td>
<td>66</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Computer room</td>
<td>74</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Assembly hall</td>
<td>63</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Sport Centre/ Gymnasium</td>
<td>46</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Store room</td>
<td>51</td>
<td>19</td>
<td>22</td>
</tr>
</tbody>
</table>

Figure 4.1: Types of Fire Threat Within Educational Premises

The above shows that the classrooms fire threat mostly consists of electrical hazards followed by staff room, computer centre, assembly hall and sports centre. However, the existence of gases in the classroom could only be through use of laboratory as a classroom. The table could assist the administrator, professionals or safety officer to consider the appropriate safety features to be introduced into those area. The types of fire hazard in most of the educational building areas are mainly electrical but areas which involve cooking and food preparation, laboratories, workshops and canteen has shown to have the gases and chemical hazard as well.
Most laboratories seem to be highly threatened by the present of the chemical substances as the source of fuel. The above graph percentages is based on the overall contribution of that particular fire threat from all the areas involved in the studies. It means that, the total percentages of each types of fire threat has been distributed among the building areas.

Using the above graph, fire safety officer and management personnel could have an overall views on the possible source of ignition and fuel to be maintained or supervised in order to keep the areas safe against fire hazard. Therefore, the fire potential problems within each areas can be dealt and focused more effectively using several graphs: Q39: B5b, Q30:B6 and Q29: B6 and also the checklist provided in Chapter 8.
The above graph shows that there are a kind of priority given by the respondent who are the hostel warden regarding the fire safety within students hostels or other accommodation premises. The highest priority is given to the dormitory followed by the dining hall (kitchen), single room, canteen, common room and utilities room (in the same group), store room, warden flat and lastly the prayer hall. It shows that the more number of human life present or involved within an area, the higher safety priority should be given to it which is parallel with the main aim of the fire safety policy that is to protect human life against fire. Another point to consider is that, the areas with sleeping activities are considered to be having higher threat therefore higher priority because of the occupant's condition where they are probably in the state of asleep and unconscious about their surroundings during sleeping hours. However, the dining room and canteen are considered having higher fire threat because of the nature of having source of ignition and fuel available within the area and also the number of people occupying at one time during the day is huge number. All that will probably create panic during emergency.
This graph is similar to the previous Graph Q36: B5a except it is referring to a wider scope of buildings within the whole educational establishment particularly the Full-Residential School. The priority ranking order was given by the administrators which could possibly be used to assist the professionals and the local authority to plan the school buildings layout within the area in a more acceptable safety standard with more mobility areas for the fire-engine to tackle any emergency. Also separating the high risk areas from the medium and low risk areas so that fire prevention steps can be applied more effective and cost to supply and install the required fire safety system able to be spent correctly in order to achieve the minimum acceptable standard. This can be achieved by using the fire risk and fire safety assessment evaluation checklist provided in Chapter 8.
The administrators in most of the educational establishment (Schools and Universities) has responded to the PartB: Q4 which shows the level of perception about the importance of fire safety objectives in achieving the safety policy within that establishment. Life Safety objective is considered to be the highest concerned and essential in most cases followed by the Educational Continuity, Property Protection, Environment and Public Anxiety falls on the same essential percentages and lastly the Economic. However, the public views on safety and economic issues should be considered by the management or safety personnel as the next very useful steps to achieve the policy. This confirmed the need to get the building occupants to be involved in giving their views and level of understanding about fire safety as part of the package to achieve the acceptable standard of fire safety within the establishment. The professionals and management team than can plan properly how to overcome any fire emergency and will be able to tackle the problems to the root sources. There is no advantage to have all the fire safety equipment installed within the buildings but none of the occupants knows how to operate them in preparing for the worst. So the budget can than be allocated for training programs or courses. It is a very useful tool to help making decisions on fire safety.

![Fire safety Objectives](image)

Figure 4.4: Fire Safety Objectives
Figure 4.5: Types of Fire Threat Within Most schools and Universities Buildings

The perception of the education officers regarding the types of fire threat for each area within the establishment is shown in the above graph. The education officers are represented by the teachers and lecturers at schools and universities in Malaysia. There are three major sources of fire threat in mostly every building in the educational establishment that is electricity, gaseous and chemical. In the graph, the total percentages are referring to the contribution of the types of fire threat exist within each areas and mostly they are threaten by electricity followed by gases and chemical. The classroom, library or resource centre, computer room, assembly hall, sport centre or gymnasium and staffroom seems to be having the electricity as the main source of threat and it contributes almost over 90%. Whereas the laboratories and store rooms are having around 30% to 60% threat from the electricity source and around 20% to 35% threat from the gaseous and chemical substances.
The Areas Within Educational Establishment Which Are Very Important To Be Considered For Fire Safety System Installation

Figure 4.6: The Areas Within Educational Establishment Which Are Very Important To Be Considered For Fire Safety System Installation

The graph above shows the building areas within a school boundary. The areas has been ranked in order of priority for the consideration in terms of fire safety. The administrative officer or the authority could use the information given as a guidelines for any safety budget allocation or improvement that need to be done for the overall school buildings and perhaps the level of supervision required. Hostel building seems to be the first priority and it is compatible with question Q4:B6 where it deals with sleeping occupants and life safety is paramount.
4.9.4 Discussion

Overall studies on the students at school or hostel reported that they do admitted the importance of fire safety in their daily environment and to have fire drill training occasionally. They also know the assembly areas available within their environment. Most of the occupants seems to acknowledge their responsibility to help those who are disabled or sick during emergency but almost all the students said that there is no disabled person within the boundary. The external environment either inside or outside the school boundary do influenced the occupants' performances.

Amongst the expectations is the wish to have higher comfort levels such as air-conditioning room that is having more controlled environment such as smell, heat and sound. Others are such as tinted glass, new furniture, bigger room size or less number or people within a room. This information is important to prove that school buildings will change and might affect the types of fire safety system installed. The education officers such as teachers and lecturers also agreed that more frequent training on fire safety or fire drill needs to be organised with the involvement of the Fire Brigade. Management and planning in fire safety amongst administrators will have to be extended so that every corner of the establishment is prevented and protected against fire and maintenance work is still undergo.

It is also agreed that the fire accidents within the educational establishment will cause a high loss impact and the blame will goes to the school education administrators and the Ministry of Education. Fire safety awareness campaign also seems to be one of the way to increase the perceptions and the importance of fire safety to the occupants and public as a whole.

4.9.4.1 Contribution To Knowledge

1. Questionnaires are not only work as a tool in any survey studies but they can be used as a mean of education or dissemination of knowledge to the public or the target population on fire safety. It was acknowledged by a few of respondents who actually involved in answering the feed back of the questionnaire. The comments were given through the open ended question No. 40: Part B1 of the questionnaire.
2. The questionnaire also acting as a method of assessing the building by the occupants and subsequently help to improve the occupants' fire safety knowledge and knowing the environment of their own areas more closely. It makes them feel important and being a part of the establishment. Also having such an exercise in answering the questionnaire has indirectly built the sense of responsibility among the respondents in keeping the education establishment safe from danger of fire.

3. The level of fire safety awareness of the building occupants within the education establishment also proven to be of moderate standard and showing a sign of improvement. Most of the respondent seems to know exactly what to do and realised the responsibilities of the administrative officers to provide the fire safety means within the buildings. They even suggested that more frequent training or fire drills, campaigns, seminars and talks to be organised with the involvement of the Fire Brigade and other professionals.

4.9.5 Conclusion

The responses gathered through the survey using questionnaire has come to a conclusion that almost all the building occupants within the educational establishment are well aware the importance of having a good fire safety training courses or frequent talks and seminars to disseminate the knowledge on fire safety. This would increase their understanding about fire safety within their surrounding environment and upgrade their awareness regarding fire risk, hazard and safety factors. Overall, most of the educational occupancies in Malaysia seems to have a fair knowledge of fire safety awareness to enable them to save own life against the danger of fire during emergency. This is because of the building design and layout is easily accessible to the external open space and most of the occupants know their ways out. It has been suggested that more training programmes and courses need to be organised and conducted among the students, teaching and general staff and administrators. As in anywhere else the theories and common sense about fire safety is acceptable but not the capability in terms of practical experience in handling fire during initial stage of emergency, knowing the types of fire hazard available within buildings areas, rescue and escape procedure, combustible materials and basic fire fighting using fire extinguishers or hose reels. It was proposed that preparation for more fire drills and
fire safety training should be conducted for all the occupants in order to expose them with some ideas on how to handle a fire emergency. Supervision of activities particularly involved the use of electrical items must be given priority. Reminders and signage about the possible danger of fire also need to be disseminated to the occupants more frequently in order to maintain the level of awareness. It also indicated that some work to improve the fire safety management and maintenance work on the fire safety equipment need to be done, generally to upgrade the fire safety services and signs within the educational establishment. Therefore, it is true that:-

a. Malaysian students and most educational personnel need to be exposed to more fire safety training and knowledge in order to be prepared to face fire incidents.

b. The level of awareness and knowledge about fire safety among Malaysian is “not inferior to the level found in the USA and the UK. It just needs to be maintained or even upgrade to a higher level because they generally aware of the danger created by fire within their environment and having knowledge or undergone training but, more effort need to be given in organising and conducting fire safety course or talks by their superiors and fire brigade officers.

c. The actions taken during emergency by the building occupants within the educational establishment has given a thought that the differences in terms of external environment and climatic changes may not required the same fire safety system to be installed within the buildings as would be required in other parts of the world. It could be right and wrong depending on the services level provided into the building areas. The example of such buildings areas are the educational buildings in Malaysia which using the ceiling fans and having widely open air ventilation through the windows and doors to create the internal environment. It is impossible to use heat detectors to perform as required because of the cross ventilation through the room but unless the room is enclosed and controlled against external environment influences.

d. There is a need to upgrade the fire safety requirement based on the changes in terms of level of comfort and services provided within the rooms. The more complicated the requirements of building performance is required, the higher level of fire safety requirement is expected to be provided.
The questionnaire can also be used as:-

i. A survey method

ii. An educational tools on fire safety (dissemination of fire safety knowledge)

iii. An evaluation tools on awareness level (an examination or test)


v. Increase the required improvement for fire safety system and occupants responsibility.

vi. Assisting in most management work of the fire safety requirement.

vii. It is to measure the acceptance and perception of the users or the occupants of the particular organisation regarding fire safety issues.

viii. An example for handling the questionnaire and to get a good response or feedback.

The involvement of the building occupants in giving the feedback about the fire safety within the educational establishment can be very useful because it helps to establish the level of response among the occupants towards fire safety with the system installed and also the management of fire safety. For example, the fire extinguishers system installed within the building will be used during emergency and maintaining it is essential. The effort to put more fire safety signs will not be left unnoticed.

With the chance of participating in giving suggestions and views about fire safety within the buildings, the occupants will feel satisfied and the future decisions made by the administration regarding building fire safety will be considered to be more practical and fulfill the safety of the majority occupants’. It also shows that their safety has been in the administration priority interest. The administrators, authorities and professionals will then understand the actual systems that should be installed and the steps to tackle the fire problems will be more comprehensive and definite in terms of reliability, practicality and economically. However, the feedback gathered through these questionnaires will be used to confirm certain issues regarding fire within the educational establishment with the evaluation checklist provided.
References:


6. Mahmut and Dorothy(5) "Investigation of a Behavioral Response Model for Fire Emergency Situation in Secondary Schools.".............


5.0 Introduction

This chapter includes a description of the use of a Delphi Group to give numerical expression to the relationships between components of the building performance and the fire safety systems. The Delphi Group representing the Malaysian Community was formed by 10 selected Malaysian individuals or students from The University of Edinburgh. The members of the Group had different educational background and qualifications. The purpose of having such group membership was to have a better consensus or perception of fire safety specifically and generally on the overall building performance in Malaysia. The order of the topics and the level of loss impact that could be caused by a fire were subjected to the appraisal of the Group also.

The existence of the Educational Establishment within a community, or an area is, to be sustained in terms of it's continuation of mission, benefits and priority for the future development. Safer buildings are needed. The budget being allocated for the education programmes should be spent wisely. The engineers and other professionals have to make decisions in dealing with the need and the uncertainties of the construction industries to reach the satisfactory level of safety and to give good value for money for what ever improvements are made or work is done. There are few particular references that can be examined for the engineer who is freshly graduated or new within the field of fire engineering or even the one who will take over other person's job and checking the standards of fire safety in such buildings that have been achieved by other engineers. However, decisions still have to be made in the solution of fire safety problems. Therefore, some question's arise: On what basis have decisions been made? and how can others understand the benefit achieved in fire safety standards and express agreement or disagreement with standards or benefit?
A method of defining the basic concept of fire safety engineering should be introduced and disseminated to all the fire safety engineers or any professional who relate to it. There is a need for a better understanding about the decision making by the professionals by a lay man or the general public. In this study, the purpose of giving a reasonable explanation as to why a certain system is needed within the area of fire safety and building performance, are well defined for everyone involved and this may assist to build a safer environment for future buildings particularly within the Educational Establishment.

5.1 DELPHI - Its Usage And Applications

The formation of the Delphi group for this study is specifically to get some consensus from the members on fire safety issues relating to the educational buildings. The study done by Martino (5) when considering the provision of Delphi estimates concluded that the Delphi estimation is not a chaotic process, but one that possesses some underlying order. This serves to give more confidence in the Delphi procedure as a means for obtaining a group consensus on a forecast. This study is related to the work done by Marchant (2) with regard to health care buildings. However, there has been several other studies that the use of Delphi technique for similar reason on other buildings or any forecasting work. A similar approach has been undertaken by T.J. Shields, G.W. Silcock and Y. Bell (4), on the fire safety evaluation of dwellings. They wrote that, Dalkey and Helmer (6) had first used the Delphi technique in a significant way in 1963 by applying expert opinions to the development of an atomic capability as part of a defence scheme. Then it was applied variously by Cetron (7) to technological forecasting and by Cetron and Ralph (8) to industrial applications of technological forecasting. Decker (10) also used a Delphi survey to forecast future economic developments in the USA. The Delphi technique has been defined by Linstone and Turoff (9) as follows:-

"Delphi may be characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem."
Linstone and Turoff (9) also stated that rather than Delphi being imposed upon a particular application, it is the presence of one or more basic properties of the application which determine the use of Delphi. Among the properties are:-

1. the problem under consideration does not lend itself to precise analytical techniques, but can, nevertheless, benefit from subjective judgements on a collective basis;

2. more people may be required to contribute to the solution of complex problem may come from diverse backgrounds with respect to experience or expertise;

3. more people may be required to contribute than can effectively interact in a direct contact situation;

4. time and cost may rule out frequent group meetings;

5. the efficiency of direct contact situation may be enhanced by a supplemental group communication process;

6. internal politics may colour the communication process;

7. group dominance is the possibility of undue influence being exerted by members with strong personalities.

Almost all the categories 1. to 7., support the use of the Delphi procedure in this study. Here a Delphi Group was used for assessing the following aspects of building fire safety:-

1. The perception of buildings in general and the priority of type of building in local community development particularly involving school buildings. (Refer to Question Level 1)

2. The Fire safety vs. other aspects of building performance in terms of priority and importance. (Refer to Part A)

3. The priority of buildings and building areas within a school. (Refer to Part B and to Part C)

4. The risk and safety assessment i.e., the type of fire hazard, risk and safety provision within each area in the school and hostel buildings. (Refer to Part D)

5. The Fire Safety Policy for a School, the Objectives, Tactics and Components. (Refer to Part E)
The questions set for Delphi Group discussions in Question Level 1 and Parts A to E are reproduced in Appendix 5.0.

5.2 The Approach of Using the DELPHI Technique

5.2.1 Why Use a Delphi Group?

Delphi actually refers to "A town in Greece but it also means the susceptible of two interpretations or with more meaning, ambiguous; of doubtful meaning; equivocal; obscure; of uncertain position or classification" (14).

The formation of the Delphi Group for this study was to discuss the uncertainty of several factors that would contribute towards the process of producing the Fire Safety Evaluation Procedure for the Educational Establishment in Malaysia. It is also used to generate useful guidance in those areas where quantitative data derived from experiment or because experience is not available (1). The purposes of the Delphi Group is to produce a framework as follows:-

1. To distil a general perception from people of different backgrounds on how to achieve a building performance and the importance of fulfilling the fire safety requirements.

2. To represent a point of view of the public. In addition some of the results may be taken as the views of individuals or the owner of a building who wishes to build a safe and secure place in which to live.

3. To help local authorities or the government in setting a policy for existing and future developments, particularly in the local development and construction field that controls the fire safety requirements for the educational establishment.

4. To assist the local authority in the implementation of the law and regulations related to building construction. To assist in the practical selection of fire safety systems for a building by the design team including architects, engineers, contractors and surveyors.
To convince the user or building owner about the importance of fire safety systems in buildings and their surrounding environment. Also to assist them to allocate a budget for any maintenance and future developments required.

To build up a ranking system for building performance for buildings to be built in a community or nation.

As a tool for decision making by the professionals in fire safety engineering and for use by the building owner and local authority as a datum.

5.2.2 Delphi Approach

There are several approaches for organising a Professional Judgement Group or Delphi Group. Some problem analysis have been undertaken in the past using this method by selecting a group of individuals who are knowledgeable in particular fields such as the Hospital Evaluation Scheme or consist only the people who have a professional qualification in the particular field of interest. However, the other step taken in managing the problems within this study is by using selected professionals of different backgrounds and expertise. (Refer to Listone and Turf(9)). The number of selected members was limited to 10 people, including the author and supervisor. The purpose of the author and supervisor participating in the Delphi group was as a guide to the rest of the members to what they are supposed to understand of the purpose of each meeting before giving any response to the questions and also to assist in any difficulties (without bias) regarding the questions set. Almost 80% of the group members were new to the fire safety field and can be regarded as representative of the lay man and yet cannot be underestimated. As the study deals with school or people oriented buildings, the introductory steps to the problems had to be established among the members and followed by more specific questions.

The approach to the members of the Delphi Group were as follows:-

i. Confirming the selected members for the Delphi Group.
ii. Set up the meetings venue and dates.
iii. Invitation letter for each meeting. (Refer to Appendix 5.1)
iv. Set up the questionnaire and topics for discussion in parts based on the number of meetings to be held. (Refer to Appendix 5.0)
v. Food and beverage for incentive and showing appreciation for their contribution of time and knowledge and to thank them for the support.

The meetings were normally 2 hours long. The group met 5 times throughout 5 months between September 1995 and January 1996. (Refer to the Appendix 5.1)

5.2.3 Selection Of Members

To select the members of the Delphi Group Meeting, several names of the Malaysian students who are still studying in Edinburgh were gathered and contacted personally. Most of them were doing post graduate studies and had been working for about 2 to 8 years in their own field of expertise. Besides, their primary and secondary educational background in Malaysia would assist in reducing any ambiguity about educational system in Malaysia. They can also compared the difference or future expectation of the local Malaysian schools with schools in the UK. With the situation of experiencing and being in two different countries with different backgrounds, facilities, weather and environment, the Delphi Group was not making any “noise” (random sources) in terms of bias or distortion of the responses. Even though, it is expected that some group members should be expert in the particular field, as it has been defined as someone practice or skilful, but for these studies, the group members involved were selected from the following (3):

1. Government officials,
2. Persons who are known to the researcher.
3. Persons who are readily available for service.
4. Professional associates.

However, the problems associated with fire within the educational establishment is not something new to most people as it involves public buildings and they probably have been in it for some considerable period of time and feel able to respond towards the total educational environment.
5.2.4 Meetings Methodology

The group meetings were carried out in the same venue all the time within the Department of Civil and Environmental Engineering, University of Edinburgh. The discussions or debate were not direct but replaced with a carefully designed program of sequentially interrogative sets of questionnaires given out at every meeting. The feedback of the questionnaire was controlled by restricting the members from any personal contact but they were assisted with interactive provision during the meeting to justify the opinions held, to question where divergent opinions exist, and to identify areas of agreement.

Basically, in the expert opinion introduced for the fire safety evaluation of the educational establishment, few steps were taken to ensure that attention and systematic treatment was given to the above methodology. Every time, a meeting was to be conducted, an invitation letter was sent out to every individual member consisting of time, date, venue, agenda and duration expected. The discussion was also conducted with initial explanation of the meeting purpose(s) and handing out only the particular set of questionnaires. They were assisted only in the matter of to question where divergent opinion exist and to identify areas of agreement. They were told not to discuss amongst themselves and the feedback was collected before the meeting dismissed. And, before the next meeting is carried out, an explanation of the previous meeting results was taken place.

5.2.4.1 The Systematic Approach.

This was made clear by the author and his supervisor participating within the group and applying the essential features of the Delphi procedures identified by Dalkey (11). The three features are:-

1. Anonymity - This was effected by the use of questionnaires or other formal communication channels thereby reducing the impact/effect of dominant individuals; The questionnaire was carefully designed to form a standardised output from the group.
2. *Controlled feedback* - This is achieved by conducting the exercise in a series of rounds between which a summary of the results of the previous round is communicated to the participants; Explanation of the previous results from the respondents was circulated, before the next set of questionnaires was given out to the panel.

3. *Statistical group response* - This is a device to assure that the opinion of every member of the group is represented in the final response. It is also a method of reducing group pressure for conformity. The process of answering the questionnaire was being conducted in a meeting room and being supervised such as in an examination situation.

With this in mind, the reliability of the Delphi techniques and methodology has been maintained throughout the studies.

### 5.3 Results and Discussion

In this study, the questionnaire sets were based from top to bottom approach of the pyramid or the triangle of decision making complexity.

![Diagram](image)

First, the *Part A*; deals with the level of perception on buildings, followed by importance of building types for community development and the priority of building performances within a building in general and then only the importance of the fire safety requirement.
Subsequent stages were focused on the following:-

**Part B:** Function of spaces or areas within the educational establishment

**Part C:** The priority of areas within the educational buildings.

**Part D:** Identification of Fire Risk, Fire Threat, Source of Ignition and Source of Fuels.

**Part E:** General Requirement of a Fire Safety Policy, Objectives and Tactics plus Components in School Building.

**Part F(5):** Safety and Risk factors Within The Educational Establishment

### 5.3.1 PART A: Concept of Buildings

**Rank of Importance For Building Development Within A Community Area.**

<table>
<thead>
<tr>
<th>Building Types</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Occupancy such as Hotel</td>
<td>3</td>
</tr>
<tr>
<td>Merchant Occupancy such as Shopping Mall</td>
<td>3</td>
</tr>
<tr>
<td>Industrial and Storage Occupancy such as Factory</td>
<td>3</td>
</tr>
<tr>
<td>Commercial and Management such as Offices</td>
<td>3</td>
</tr>
<tr>
<td>Educational and Assembly (Schools and Universities)</td>
<td>5</td>
</tr>
</tbody>
</table>

Table 5.0: The Importance of Building Types for Community Development

where:- 1 = not important 2 = quite important 3 = important

4 = very important 5 = essential

The table 5.0 shows that the educational buildings such as schools and universities are considered to be an essential building types for any community development. It means that any development project in any existing community should always take into consideration the educational buildings as part of the major requirements. Whereas the other buildings types are considered to be important buildings in a community as well, but only if the community has already being provided with all the basic requirements for it’s development such as schools and including all the other essential buildings. However, the local authority and the people of the community should be able to make a decision whether to have the rest of the buildings such as hotels, shopping malls, offices and factories to be built, particularly for employment opportunity and future advancement. Normally these are built by the private sector but they have to be approved by the local government. Therefore the table above can be used as a reference to show that educational buildings are the highest priority compared to the rest of the building types and attention of it’s development and
maintenance should be focused more by the authority and the people within any community.

There is another attempt made to assess the importance of the buildings mentioned in the above table by comparing the importance with a given scenario. The scenario is only to assist the Delphi group to have certain ideas and limitations in order for them to give their perception about the buildings. The scenario is as follows:

**Scenario:** There are few housing community population newly built with some provision such as shop houses, banking branches, means of transportation, clinics and primary schools in each area. The communities are having all range of ages of population from children, teenagers, working man and woman, and old folks. What do you think the community would like to have built within the community for the next development that is priority to all of them?

Where:- 1 = most priority and 2, 3, 4 and 5 less priority

The result from the discussions, the Delphi group decision can be generalised into the following rank order.

<table>
<thead>
<tr>
<th>Building Types</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Occupancy such as Hotel (A Hotel)</td>
<td>5</td>
</tr>
<tr>
<td>Merchant Occupancy such as Shopping Mall (A Shopping Mall)</td>
<td>3</td>
</tr>
<tr>
<td>Industrial and Storage Occupancy such as Factory (A Factory)</td>
<td>4</td>
</tr>
<tr>
<td>Commercial and Management such as Offices (An Office Block)</td>
<td>2</td>
</tr>
<tr>
<td>Educational and Assembly (A Secondary School)</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5.1: The Importance of Building Types For A Given Scenario

Based on Table 5.1, again educational buildings were selected to be the most important building type and focused on, in this study. This confirmed that the study on fire safety for educational buildings is very important.
5.3.1.1 Loss Impact on Buildings

<table>
<thead>
<tr>
<th>The Impact and Loss Caused by Fire</th>
<th>Hotel</th>
<th>Shopping Mall</th>
<th>Factory</th>
<th>Commercial and Offices</th>
<th>School and University</th>
<th>Overall Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>To The Owner</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>yes</td>
</tr>
<tr>
<td>The Local Community</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>yes</td>
</tr>
<tr>
<td>The Local Government</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>yes</td>
</tr>
<tr>
<td>The National Level</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>International level</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>no</td>
</tr>
<tr>
<td>Centre of Emergency for Natural disaster</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>A Place For People’s Gathering Activities</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>Community Development without the building type</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>n</td>
<td>discuss</td>
</tr>
</tbody>
</table>

100 % Involved With Fire

<table>
<thead>
<tr>
<th>Continue mission by other building</th>
<th>y</th>
<th>y</th>
<th>y</th>
<th>y</th>
<th>y</th>
<th>yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effecting the individuals working in it</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>yes</td>
</tr>
<tr>
<td>Effecting individuals outside the building</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>Effects the community development</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>Effects the local governments decision on other development</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>n</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>Other peoples performance effected during recovery</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>Matters to the federal or national level</td>
<td>n</td>
<td>y</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>Shaken the government position to public</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>Effects the international budgets/sponsorship</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>n</td>
<td>y</td>
<td>discuss</td>
</tr>
<tr>
<td>Close permanently, the nation can develop successfully</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>y</td>
<td>discuss</td>
</tr>
</tbody>
</table>

Table 5.2: Loss Impacts On Buildings

By referring to the Table 5.2 above, it is seen that if all the types of buildings mentioned are involved with fire disaster, the impact will be as follows:-
i/ The owner of the buildings will definitely be affected by a direct loss, for example financial, property, may be human life and probably the mission.

ii/ The local community development will be affected by the accident in terms of its quality of construction, supervision or maintenance of the work done by the professionals. Even the local authority who gives the approval could also be questioned for allowing the operation of such building if it is found to be unsafe. Other impacts are such as unemployment, loss source of income or economy, create social problems in a long run, and living in fear.

iii/ The local government will also be affected by the fire disaster in terms of external investment by foreign country which probably have a higher level of fire safety implemented by their government policy in their country. In another word is that the investment capital will be diverted to some other places, the trust of the people will be decreased on the government administration resulting political issues.

iv/ National development has a higher probability of not being affected by the accident as the whole country needs to be developed in so many other ways, other buildings of the same kind will probably replace the shortfall. Therefore, by referring to the previous discussions in part A: F: Q6, the agreement on this question is acceptable. (National development not much affected by losing a hotel building or shopping mall, factory and commercial and office buildings). However, the educational buildings such as the schools or universities do affect the national level of government as they are under the federal government administration and the Ministry of Education. Educational buildings if involved with fire will create different issues all together compared to other types of buildings. This is because the children are the most valuable heritage without a price and which will have the future of a country in their hands.

v/ The international community would not be affected by any direct loss because the fire disaster in those buildings especially if it does not involved human life but the impact may be faced only by the local investors and local government. Unless some one or something that is recognised world-wide
as an important figure in the international community is involved in the fire accident then only will it have some impact to the international community.

vi/ It was agreed by the Delphi group that Hotel, Shopping Mall, School and University buildings would be used as emergency centre for any natural disaster.

vii/ It is also agreed that the function of a hotel, shopping mall, school and university buildings are the places for people's gathering activities which means that these buildings are people orientated buildings and the main objective should be life safety.

If hotel, shopping mall or factory buildings are 100% involved with fire, then the Delphi group agreed that their mission can still be carried out by other hotel, shopping mall and factory buildings. Of course, the accident is affecting the individuals who are working in the buildings and even though the particular building will be closed permanently, however the nation can still be developed successfully. But the schools or universities and commercials or offices buildings cannot continue to be developed. Offices and commercial building which are considered in this contact include the government offices and other archive buildings.

The fire disaster will certainly affect the other people in other types of buildings by causing unemployment and a decrement in other related activities involving the continuation of the mission of the building. The development of the community within the area will also be affected by it. The impact on local government may affect the decision making on other development programs. The performances of pupils will be affected during the post-fire recovery period of time. For example; if parents who work in a hotel, are now unemployed, then a particular nucleus of society will then have difficulties in sending their children to school and to provide good food for the family. In time this difficulty will destroy the community. The hotel, shopping mall and factory may not make any impact on the federal and national levels because they are normally owned by individuals or companies in the private sector. They will only affect the federal or national level if the building is built and approved without having adequate safety requirements by the officers who are working with the implementation of the government policy on building.
This matter is very important because the government is elected by the public with trust and high expectation of the well being of the country, so any fault in the system may affect the moral and political issues at the national and international level. However, it won’t upset the government position directly if the buildings are owned privately and have no political importance. Nevertheless, the destruction of private industry could have an impact on the national “well being” if private ownership could be enabled by government grants and other incentives. There will not be any effect on the international budgets or sponsorship to replace the damaged building types except schools and universities and some government office buildings.

5.3.1.2 If 100 % of The Building Involved With Fire

Delphi group also decided that educational buildings will certainly affect the performance of the people within the community if it is involved 100% in any fire accident. The effects are as follows:-

1. Parents are affected by the changes of their normal schedule if children are not at school.
2. Social problems within a community such as teenagers wasting time hanging around shopping malls, leisure parks, games arcade or other public areas.
3. Major examinations would be delayed and other process within the education establishment are interrupted.
4. Employment for those with a proper qualification will be left undeveloped and may cause a decrease in the quality of work.
5. Future generations will probably be under negative influence and the country will gradually degrade in all aspects. This is not likely if only one school is 100% involved. However, any increase in fire losses generally could bring about a general decline in educational standards.

The matter of fire accident involving the educational building absolutely will affect the national level especially the Ministry of Education which is directly under the government administration. Whereas other building type could be owned by a private company probably affect only one particular party, but still the Ministry of Education must ensure that all the education buildings are in good condition and safe in operation. For this reason, the government really need to put more effort to
ensure that the trust of the people are sustained and they are in full confident with the way the government runs the country as the opposition parties may influence the people to go against the government with the coming general election that will lead the country.

Educational buildings can also affect the budget of an international sponsor in terms of loans or donations for building up any educational establishment particularly in a developing country such as Malaysia. So the issue of safety against fire within the educational establishment is not only involved in the national organisation but perhaps in the international community as well.

The educational establishment will need to be reinstated. Otherwise the national development program could be affected. The nation can only be developed successfully once the educational problems are solved to certain extent and not left unattended. The people will have to be educated in order to cater the future needs of the country. There won't be any prosperous and healthy country if the citizens are being administered by people who are naive or unqualified.

Therefore, steps to seriously consider the fire safety of educational buildings will need some kind of risk assessment or evaluation procedure on it's safety condition. This discussion is important as fires and related incidents can affect all people (particularly school children), employees (teachers, lecturers, administrative staffs, general workers, etc.), shareholders (government and international organisation), customers or suppliers of the educational equipment and appliances and other related agencies such as school bus companies and society (environmental) where surely the need for risk assessment is clearly apparent (12).

5.3.2 Part A: General Perception of The Building Performances

Generally in the following questions Q:1, Q:2, Q:3, Q:4 and Q:5 represented in Appendix 5.0 Part A, are looking at the importance of building performance within a building. A rank of priority of the building performances has been obtained. This is needed to rank the position and importance of fire safety amongst the services within a building. This rank order has been derived from a group of people with different
professional backgrounds, knowledge and interests. Their perception of fire safety and other building performances are very useful as a base or indicator, of the perceptions of people in all other engineering fields and particularly the perceptions about building within a community, a nation or even at an international level. It provides a reference for any professional person, local authority or building owner about on how to examine a building in some detail. It may be that a future development, alteration or change during the construction of a building will result in a better building with respect to all building performance requirements.

In Part A, the perception given by the Delphi Group members can be categorised into several stages:-

a) Building performances in general categorisation of other building performances under fire safety.
b) Relationship between the fire safety and other building performances.
d) Fire safety position amongst the building performances.
e) Comparing between the building types for the level of importance of the building performances.
f) Loss impact of fire on individual, community, nation and internationally by the types of buildings based on number of population.

5.3.2.1 Based On The Questions (Refer to Appendix 5.0 : Part A)

A) Building Performances In General

Q1: Knowledge of Buildings by the Public: General Ranking of Building Performance. (Refer to Appendix 5.2)

In general, the ranking of the aspects of building performance can be categorised into 14 different parts as shown in Table 5.3. However, the overall rank which has been analysed through the Delphi Group gave structural stability the first priority, followed by potential risk or accident and in third place fire safety. The least priority of the aspects of building performance was the tactile and anthropology-dynamic aspects.
Giving structural stability the first priority amongst the other building performances seems to be acceptable and rational. Generally, without a good structure, a building will not be able to stand firm, not even during fire emergency, but also in any other condition. Whereas, a potential risk or accident should be considered from the beginning of the design stage, then through construction and throughout the existence of the building. Therefore, a brainstorming session was found to be an important activity for gathering information from all other sources which builds up the whole system of a building. Then only, fire safety came into the scenario of building performance even though it could be ranked higher or lower as it interacts with other parts of building performance. For example, structural stability. The building should be able to stand for a certain period of time under fire conditions (fire resistance) to allow evacuation and rescue procedures to take place.

It is also the same with the tightness of the building envelope. Here, carelessness or lack of caution in constructing the buildings may caused inefficient pressurisation or operation of other smoke control systems, serious deficiencies can be caused by a lack of care in making and installing openings such as doors and windows. The building's performance should then be taken seriously into consideration so that managerial or building professionals can make any future improvements according to or based on the suggested rank order. These will also depend on the nature of the work that needs to be done and the status of the financial budget for the building.
In Q.1; the perception of durability and economics came to be the least priority of all the other building performances. This suggests that improving the life of the building or achieving a greater cost efficiency in the procurement of the building are not important factors.

However, durability and economics are very important as they are involved in almost every aspect of building performance. That is also the reason why several studies has been focused on cost effectiveness, practicality and good value for money which will be spent on building performance particularly in this case the fire safety systems. Example of the cost effective studies are given in the article based on comparison of evaluation schemes by Marchant (15).

There are several uses of the above table:

1/ To refer as a basic foundation for the importance of all aspects of the building performance in a building.

2/ To assist in taking action or making decisions for any kind of improvement or maintenance work of the building performances which need to be carried out.

3/ To assist in the allocation of the budget or expenditure for the existence of the building in a critical economic condition or having extra money to spend for specific purposes.

4/ Knowing exactly what a building consists of, particularly for people without buildings or constructions knowledge.

5/ Structural stability is the most important building performance that is first to be considered in the design of a building.

Therefore, with this reference, one can look at a building as a set of functional systems to ensure the up grading and maintenance work is carried out properly. The responsible party will be aware of the priority of systems when making the building safer. Another point is that the owners will know the best way to spend their money wisely in order to get the exact level of comfort and facility they require as perceived by the Group.
5.3.2.2 B) Categorisation of The Building Performances Under Fire Safety

Q2 : Building Performances That Are Categorised Under Fire Safety.
(Refer to Appendix 5.2)

This question is more related to the relationship between fire safety and other building performances where the specific aspects of building performance make a specific contribution to fire safety. Which of the stated building performance characteristics can be categorised as part of fire safety? Some of the building performances can be considered alone or parts of the overall category of the fire safety requirements in a building. Fire safety will act as the main objective and the rest of the building performances categorised under it as the contributors to fire safety. By referring to the Appendix 5.2 (Delphi Group Part A:Q2:) structural stability, tightness of building envelope, acoustic qualities, durability and economics are not being categorised solely under fire safety. This shows that these characteristics are capable of standing alone and probably having a slight direct effect from fire. They should be considered to be the priority in constructing a building and probably have the same degree of importance as the fire safety requirement.

Even though the structure and tightness of the building envelope can be considered as part of the fire safety requirement they can stand more significantly as on their own. However, they contribute toward fire resistance and affect smoke control systems respectively. Whereas acoustic considerations can affect the sound of the alarm system by enhancement or elimination. This is very important for the evacuation process. However, acoustic deals with the comfort sound level of the area and surroundings within certain boundaries. Fire safety will probably have to depend on availability of finance in order to provide or upgrade the performance of systems in a building.
5.3.2.3 C) Relationship Between The Fire safety and Other Building Performances. (Refer to Appendix 5.2: Q3)

<table>
<thead>
<tr>
<th>Building Performance</th>
<th>More Towards Fire Safety</th>
<th>More Towards It’s Own Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Building Location</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Flexibility</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Hygiene/ Pipe Work</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Interior Finishes</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Acoustic</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Thermal</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Structural</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Potential Risk</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Tightness</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Vision</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Durability</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Tactile and Disabled facility</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Energy Consumption (Power Supply)</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

where: 0 = not applicable  1 = not important  2 = quite important  3 = important  4 = very important  5 = essential

Table 5.4 : Fire Safety and Its Relationship with Other Building Performance

The above table shows that most of the building services or building performances do have some kind of connection with fire safety and yet at various degrees or levels. Generally, the Delphi Group agreed that some aspects of building performance contributed strongly to fire safety. There are:-

a/ Security
b/ Interior Finishes
c/ Acoustic
d/ Potential Risk/Accident
e/ Tightness
f/ Durability
g/ Energy Consumption or Power Supply.

i. “Security” is important to fire safety as it provides surveillance and keeps the areas within the boundary of a building secure and safe from any intruders. This helps in reducing the fires caused by arson. Guards and surveillance cameras are the principal components of effective security particularly during off working hours and when the building is occupied. It may also act as fire detection system when
connected to an alarm system. Besides, it is very important to avoid such tragedy like on the 12 March 1996 where 16 children and one teacher were shot dead and many more injured at Dunblane, Scotland.

ii. "Interior finishes" is another main consideration that may be the source of fuel to any kind of ignition. They really need to be selected properly for each area of a building. Interior finishes are important to fire safety (only if it is being considered carefully) because they helps to control the surface spread, fire growth and will affect the safety of escape routes. Mobility of people could influence the choice of finishing materials. The colour scheme and texture of the interior surfaces can also be very useful to enhance the psychological aspects of surfaces and the comfort level of the occupants and response to emergency signals.

iii. "Acoustics" or sound levels within an area is also considered to be an essential part of fire safety as it is useful in the earliest stage of fire safety performance by giving warnings in the surroundings in the case of fire emergency. The safety of the building occupants can be increased or decreased by using the alarm system which provides sounds that are supposed to be heard by all of the occupants of the building.

iv. "Potential Risk or Accidents" must be assessed throughout the life of a building and the activities within them. The assessment process starts from an early stage of construction period, followed by commissioning and maintaining the buildings. The potential risk of accident must be identified and precautionary steps should be taken (ready or standby) to avoid any ignition which is unwanted such as fire or smoke. It is important in achieving both fire safety and general safety within the building.

There is a need to make it clear that this aspect of performance is to do with all non-fire accidents and that their prevention contributes to a reduction in fire (safety) accidents.

v. "Tightness of the Building Envelope" is useful in the effectiveness of smoke control systems and the control of fire spread which is connected directly to the fire safety requirement. Therefore, supervision during the construction must be carried
out in order to ensure the quality of the workmanship for the standard required by fire safety system(s) in the building. A control over the permeability of the barrier is very important. May need to specify leakage for smoke control systems and/or for volumetric extinguishing systems (gaseous and foam systems). In an enclosed area, any openings in the walls such as doors and windows will allow smoke to flow into refuge areas or escape routes unless sufficient airflow's through the open doors or windows to prevent smoke backflow. John H. Klove (13) specifies leakage in the design of smoke control systems as the area of these leakage paths depends on workmanship and the example of typical leakage areas for walls and floors is explained. He also said that a critical velocity of approximately 800 fpm or 4 m/s would be required to stop smoke from an intensive design fire with an energy release rate of $8 \times 10^6$ Btu/hr (2.4 MW).

vi. "Durability of building" is very closely related to building structure, materials, types of construction and fire safety. As long as the building structure is strongly standing on it's ground and can take the proper weight of the building load itself, interior and the activities within it then the building and occupants are safe to use it.

vii. "Energy consumption or the power supply" into the building are also features considered to be having an important role for the fire safety. This normally assists in the evacuation of the occupants and the escape route design by facilitating the operation of emergency lighting, smoke detectors, automatic escape door releases and escape signs. An adequate separate power supply back up or standby should be provided for the emergency lighting or any important electrical systems such as the computer and the automatic fire safety systems. The results will increase the reliability of the performance of the fire safety systems directly or indirectly as a whole.

5.3.2.3.1 Other Important Aspects of Building Performance

The following are the aspects of performance that relate to fire safety but where greater definition is needed to allow appropriate levels to be identified for their specific performance contribution before considering interactions with fire safety or other aspects of performance.
<table>
<thead>
<tr>
<th>Important Building Performance</th>
<th>Overall Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Flexibility and Fixity In Space Use</td>
<td>4</td>
</tr>
<tr>
<td>b. Aspect of Hygiene and Pipe Work</td>
<td>4</td>
</tr>
<tr>
<td>c. Structural Stability</td>
<td>4</td>
</tr>
<tr>
<td>d. Potential Risk and Hazard/ Accident</td>
<td>4</td>
</tr>
<tr>
<td>e. Energy Consumption/ Power Supply</td>
<td>5</td>
</tr>
</tbody>
</table>

where: 1 = Not applicable, 2 = Quite Important, 3 = Important, 4 = Very Important, 5 = Essential

Table 5.5: Other Important Specified Building Performance

Energy Consumption/Power Supply provides:-

i. Electricity for all the electrical appliances and also lighting.

ii. Ensure that there is enough heating or mechanical ventilation and continuation of mission within the existing building.

iii. Useful for the electrically fire alarm, fire detector such as the surveillance camera for security and communication.

Potential Risk/Accident must be considered:-

i. From the beginning of the building design stage, follows by construction and as long as it's existence.

ii. Ensuring that the possible precautionary steps are taken and ready to reduce the impact of any unwanted event or emergency.

Structural Stability important for:-

i. The stability and strength of the building as a whole.

ii. To cater the load imposed on the building structure by it's own weight, wind, rain and activities within the building.

iii. Preventing collapse of a building in case of fire emergency.

Aspects of Hygiene or Pipe Work:-

i. Important for drainage and sanitary system for the building.

ii. Providing a healthy place to live in.

iii. Avoiding the possibility of flood or dampness condition which can weakening the structure strength.
Flexibility and Fixity In Space Use:-

i. Assist in terms of ease of escape during emergency to the nearest safe areas.

ii. Ensuring the level of comfort for the occupants of the areas is achieved by proper arrangement of the furniture and interior.

iii. Easy to change the area for alternative functions or purposes whether needed currently or in the future. (i.e.: School Assembly Hall can be used as student assembly area, examination hall, exhibition and cultural performances, where it is used as a multi-purpose area).

All the above building performances are also considered to be as important as fire safety because they contributes towards the complete set of components of a building that are necessary for the building to function efficiently.

5.3.2.4 D) Fire Safety Position Within The Building Performances.

Q.4: Fire Safety Position Amongst The Other Building Performances.

(Refer to Appendix 5.2)

<table>
<thead>
<tr>
<th>Delphi Group 1</th>
<th>Rank Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isma</td>
<td>2</td>
</tr>
<tr>
<td>Amir</td>
<td>4</td>
</tr>
<tr>
<td>Isham</td>
<td>3</td>
</tr>
<tr>
<td>Fadzil</td>
<td>2</td>
</tr>
<tr>
<td>Md.Som</td>
<td>4</td>
</tr>
<tr>
<td>S.Hussien</td>
<td>5</td>
</tr>
<tr>
<td>Basir</td>
<td>3</td>
</tr>
<tr>
<td>Naim</td>
<td>3</td>
</tr>
<tr>
<td>Dzul</td>
<td>2</td>
</tr>
<tr>
<td>Eric</td>
<td>5</td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>3.3</strong></td>
</tr>
</tbody>
</table>

Table 5.6: Fire Safety Position Amongst The Building Performance

The average ranking score given by the Delphi Group is 3.3 (refer to Q.4: Table 5.6 above). This rank order seems to be very convincing and parallel with the answer and discussion given in question 1.(Q.1),(refer to Table 5.3) where it is ranked number 3. This shows that most of the public and the professionals should have similar perception about fire safety in buildings and it's performance expectation.
They also will be able to have a clear picture what and how to decide on the importance between all the stated building performances. The rank of priority will assist individuals to make decision on building in general and which of the system should be given more attention if it was decided to improve the current or future condition of the building. A common understanding about the importance of the components of building performance will create a better relationship between lay and professional people.

5.3.2.5. E) Comparing Between The Building Type For The Level of Importance of the Building Performances.

Q.5: Comparing Between The Building Types With The Building Performances. (Refer to Appendix 5.2)

Looking at the (Table 5.71 to Table 5.75 of Q.5) the chosen types of building shows a slight different in the importance of the building performances required. The structural performance is still the top priority. This confirms the previous ranking system proposed for the building performances particularly the structural stability. However, there are some slight changes between the essential requirements for each type of building. The number and order of essential building performances varies mainly according to the function and purpose of the building.

Hotel buildings seems to require a much greater number of building performances at the essential level. This is true and rational if we look at the huge investment that normally made by the hotel owner to accommodate their customers to the highest comfort level possible. This is very important in terms of encouraging more customers for the business continuity and also for the marketing strategy. Therefore, more building services and other building performances are needed to achieve the objective of a hotel. The better services provided, the more customers will use the hotel rooms. As a "people intensive" building, a hotel needs better fire precautions than some other types of building.

Building location also seems to be affected by the types of building function. For example the developer of a shopping complex will certainly consider the building
location as an essential requirement because it will assist the marketing strategy and convenient to the customers who will be attracted to shop. However, amongst the types of building, the school and hotel building need serious consideration on most of the building performances, particularly dealing with human comfort.

5.3.2.6 F) Loss Impact of Fire On Individual, Community, Nation and International Levels by the Types of Buildings Based on Number of Population.

Q.6: Perceptions Based On A Population of 1 million People Towards The Importance of Building Types. (Refer to Appendix 5.2)

This part of the question is using a fire scenario based on a catchment area as a guide line to the Delphi Group perceptions. The area is divided into 2 parts:- (Refer to Appendix 5.0:Part A)

1. A population of 1,000,000 people. i.e.; in a city
2. A population of 1,000 people. i.e.; in a small village community

The Delphi group members had to determine the importance of the different building types within those community population and also look closely at the possible loss impact that may have on the owner of the building, the local community, nation and international community as well.

Scenario 1: A population of 1,000,000 people.

<table>
<thead>
<tr>
<th>Building Types</th>
<th>Rank of Importance Within Community</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>Secondary School</td>
<td>1 (Priority)</td>
<td>3.5</td>
</tr>
<tr>
<td>Shopping Complex</td>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>Factory</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>Office Building</td>
<td>3</td>
<td>2.5</td>
</tr>
<tr>
<td>Hotel</td>
<td>3 (less priority)</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Table 5.8: Building Importance Based On Scenario 1.

The average values given in the table above are reflecting the rank of importance for the building types. The rank shows that the boarding school is chosen to be the
most important building to be looked after in the community. The reasons for the outcome (results) could possibly be because of the following:-

a. Boarding school is administered by government.
b. Contains of school children from the community or else where.
c. The children's life is seem to be more fragile and vulnerable than the lives of other people.
d. Education is the most important activity.
e. Without school, the effects will not only be on the children but also on other people such as parents, public and on the economy and future development of the community.
f. May cause problems with political, social, moral and physical and psychological development.
g. Number of boarding schools within the community are probably too few and in the Malaysian context, only selected students are able to study in such a school. The students being selected are usually good in academic, sports and other skills.
h. It provides benefit not only to every individual but also to the whole community and beyond, including the achievement of other purposes in these building types.

The boarding school is considered to be very important but not essential to the community. This is probably because of the education system is the same in all other secondary schools at the same level and is governed by the Ministry of Education. The difference is only the hostel accommodation which is being provided or built within the school compound.

The shopping complex, offices, hotels and factory is ranked important, meaning that their existence is needed basically after considering the need of the community development.

Q.6(b): Generally, the Delphi Group agreed that all of the types of building mentioned would cause a significant loss impact to the owner; Offices Building, Hotels, Factory Boarding School and Shopping Complex.
Table 5.9.1: Building Types: It's Rank Order, Importance and Loss Impact (1,000,000 people)

<table>
<thead>
<tr>
<th>Building Types</th>
<th>Rank</th>
<th>Importance (Overall)</th>
<th>Level Of Loss Impact On Owner</th>
<th>Community</th>
<th>Nation</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Shopping Complex</td>
<td>2</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Office Building</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Hotel</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Secondary School</td>
<td>1</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

The Impact to the community if one of the building types 100% involved in fire is given in the table above, for a limited number of building types. The Secondary School (Boarding) was considered to be the most important asset and one where the loss impact would be greatest.

The loss impact that a hotel fire can cause to the community will probably be less significant. This is due to the situation that other hotels can cater for the shortage and there won't be any serious social or political issue brought up by opposition parties. The loss that perhaps the people within the community face will be the non-availability of job for certain individuals and may be a lower number of tourist, lower reputation, and financial difficulty but it does not affects the local government as much as the impact of the loss to the owner or individuals.

In such a huge number of population, the loss impact to the nation if those building types 100% involved in fire is getting less. Since the boarding school is some kind of a unique type of building within the population, a serious consideration in terms of safety against fire is very important as it may cause significant loss impact to the nation. This is due to the situation that the children studying within that building are normally selected from amongst the best in their previous schools. It is still a matter that the responsibility of the federal government or the Ministry of Education needs to cater for and take into account the condition of the boarding schools. Where as the other types of building such as the hotels, shopping complex, office building and factory only cause the nation a relative loss impact or nuisance loss impact as stated.

Actually, the national loss impact will be in terms of trust and confidence in the work done by the government by the people. This usually relates to the policy and
regulation for buildings. Therefore, the government should ensure that the building regulations and acts which are supposed to be implemented within the community must be followed by the professional or every individual that is involved in construction. It is important to maintain the reputation of government and the trust of people on it’s administrative work. As a poor performance will definitely affect government in terms of politics, moral issues and the local or the overseas investors into the country.

However, if those building types are 100 % involved with fire, there will be some kind of interest by the international community particularly the dissemination of news through common media. It will brings the attention or focus of the international community about the negative perception which will affect the country or government reputation world-wide. The nuisance or trivial loss impact that possibly affects the international community if fire accidents do occur in those buildings, show that the issues of safety is an international issue and that someone should take some precautionary steps or actions that will help to reduce or solve the problems. Normally, if there are any overseas bodies involved directly in the fire accidents within those buildings type, the branch company of the origin country will feel the loss impact.

Boarding school is considered as an international issue which will also affect the international organisation who is concerned about the well being of the children and may act to influence education policy in some countries.

Q.7: Perceptions Based On A Population of 1 thousand People Towards The Importance of Building Types. (Refer to Appendix 5.2)

Scenario 2: A population of 1,000 people.

Overall the buildings stated are considered to be essential to the 1,000 people community. This is probably because of the number of buildings within the community is one of each type. The loss impact if any of the buildings involved with fire is gradually decreases from the catastrophic level down to a trivial loss impact. However, the boarding school particularly, is giving a significant loss impact to the
level of a nation which is also considered to be the most important building in that population of community. If a boarding school is 100% engulfed by fire, it will affect the population in terms of their need to reorganise every aspect such as finding allocation to build a new building, or relocation, transportation for the school children, parents will have to stop work for a certain time, and the local authority will have to concentrate more on the development of the educational building than any other buildings. Therefore, the perception of the importance based on a population of 1,000 people still favours to the educational building particularly the school.

<table>
<thead>
<tr>
<th>Building Types</th>
<th>Rank</th>
<th>Importance</th>
<th>Owner</th>
<th>Community</th>
<th>Nation</th>
<th>International</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Shopping Complex</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Office Building</td>
<td>2</td>
<td>5</td>
<td>7</td>
<td>5</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Hotel</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>6</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Boarding School</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

Table 5.9.2: Building Types: It's Rank Order, Importance and Loss Impact (1000 people)

- **Levels of Importance**
  - 0 = Not applicable
  - 1 = Not Important
  - 2 = Quite important
  - 3 = Important
  - 4 = Very Important
  - 5 = Essential

- **Levels of Loss Impact**
  - 0 = not applicable
  - 1 = trivial
  - 2 = nuisance
  - 3 = important
  - 4 = significant
  - 5 = disruptive
  - 6 = severe
  - 7 = catastrophic

5.4 **PART B:** Function of Spaces or Areas Within the Educational Establishment. (Refer to Appendix 5.3)

**Q.1:** The answer given by the Delphi group varies but the average age for the Fire Safety Knowledge to be disseminated to children is 7 years of age. It is the earliest age that fire safety knowledge will have a strong influence on the children. This age coincides with the age for children to start going to a proper primary school in the educational system in Malaysia. Even though this study is focusing mainly on secondary school, the value of response of younger children age should not be underestimated. The sooner fire safety knowledge is being taught at school the better the chance of making the children aware of the danger of fire and if possible avoid any fatal accident involving children or human lives.

**Earliest age to educate children with Fire Safety Knowledge**

7 years
Primary school operates normally daily without any personal accommodation or boarding basis. This practice is particularly referred to the Malaysia primary school system. The children are on their own when they are on the primary school premises and only being looked after by teachers. They normally spending 6 to 7 hours within the system each day. But this is not the case for secondary boarding school in Malaysia. Most of the boarding school children will be spending their entire 24 hours within the school boundary. They sleep, eat, play and learn within the school. The year is planned on a semester or term system. There is also time where they are on their own without teachers particularly in the dormitory or living accommodation. These are the reasons why this study is more concerned on the secondary boarding school but the results of the study should be applicable to any level of the educational system. (Refer to Appendix 5.3: Part B)

The outcome danger of fire is likely to be more serious for those children in the secondary school compared with those who have a lesser exposure to the school fire threat. Therefore, this question can be used as the guide line regarding fire safety knowledge to be taught at school if age is to be considered. It could also be used to convince the members of the public and parents of the need to give fire safety information to their children. It is hoped also that this study will help to avoid any disagreement. The Ministry of Education could implement a certain programme on fire safety to be carried out in their interest and for the safety of the children.

Q.2: This question is trying to get the overall views of the public regarding the importance of the types of school. In the previous, or first part, of the Delphi group discussion, educational establishments or the schools captured the priority concern of the public compared to other kind of building types for any community development. Once the school has established it's importance amongst other types of building, then the question is based on which type(s) of school is to be given the priority because it may cause a catastrophic loss impact on the community and nation if a fire disaster struck.

<table>
<thead>
<tr>
<th>Types of School</th>
<th>Rank of Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nursery</td>
<td>5 th</td>
</tr>
<tr>
<td>Primary School</td>
<td>4 th</td>
</tr>
<tr>
<td>Secondary</td>
<td>3 rd</td>
</tr>
<tr>
<td>Boarding Secondary School</td>
<td>1 st</td>
</tr>
<tr>
<td>Higher Institutions</td>
<td>2 nd</td>
</tr>
</tbody>
</table>

Table 5.9.3: Catastrophic Loss Impact On The Community and Nation
Table 5.9.3 shows that the secondary boarding schools were selected for the 1st. priority in the study of fire safety for educational building because of the confinement of the area and the time spent by the school children within the establishment. Other strong reasons are that the school is occupied normally by selected students from various communities and locations. They are selected according to their achievement, or merit, in education and Co-curricular activities, family economy and social status. So, if anything happened to the children in these particular schools, it would certainly affect the whole community of Malaysia. Therefore, the accidents will also affect the nation by changing it's educational policy.

Consideration should be given to the following:

a. Age of the occupants.
b. Capability:- mental, physical and psychological.
c. Manageability
d. Number of occupants within an area
e. Availability of assistance.
f. Activity and working nature of environment
g. Risk available
h. Safety available.
i. Loss Impact in the case of an accident (Individual/ organisation/ community/ nation and international).
j. Replacement, maintenance and economy (value for money).

Please note that the aim is to reduce the level or number of life loss in fire accidents to an acceptable number within a period of time. For example, in 10 years, the number of people killed in fire accidents is 1000 and this should be reduced to 100 within the next 10 years.

Q.3: The types of school and level of education that should be the priority and the best model for educational establishment in fire safety study is the Boarding Secondary School followed by the higher institutions, normal daily secondary schools, primary school and nurseries, in sequence. (Refer to Appendix 5.3: Part B)
Types of Institutions | Rank Order
--- | ---
Boarding Secondary School | 1st
Higher Institution | 2nd
Normal Daily Secondary School | 3rd
Primary School | 4th
Nursery | 5th

These shows that the research undertaken seems to be aligned with the Delphi group perception that the full board secondary school is very important and the best example as reference for any educational studies particularly involving the fire safety requirements.

Q.4: The Delphi group has agreed that the best level of education to be used as a reference by policy makers on fire safety are as follows:-

<table>
<thead>
<tr>
<th>Number of Delphi Group. members</th>
<th>Level of Education</th>
<th>Percentages %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fadzil</td>
<td>Secondary school with hostel/ living accommodation</td>
<td>50%</td>
</tr>
<tr>
<td>Dzul Haimi</td>
<td>Primary &amp;Secondary School with living accommodation</td>
<td></td>
</tr>
<tr>
<td>Eric</td>
<td>Secondary school with Hostel / living accommodation</td>
<td></td>
</tr>
<tr>
<td>S. Hussien</td>
<td>Secondary School With Hostel</td>
<td></td>
</tr>
<tr>
<td>Isham</td>
<td>Secondary School With Hostel</td>
<td></td>
</tr>
<tr>
<td>Isma</td>
<td>Higher Institutions(Colleges and universities)</td>
<td>30%</td>
</tr>
<tr>
<td>Md. Som</td>
<td>Higher Institutions</td>
<td></td>
</tr>
<tr>
<td>Basir</td>
<td>Higher institutions</td>
<td></td>
</tr>
<tr>
<td>Wan Naim</td>
<td>Secondary school</td>
<td>20%</td>
</tr>
<tr>
<td>Amir</td>
<td>Secondary school</td>
<td></td>
</tr>
</tbody>
</table>

Table 5.9.4: The level of education to be used as reference

The Full Boarding School 50%, Higher Institutions 30% and Secondary School 20%. This shows that in table 5.9.4, the overall decision, the boarding school is the best level of education to be the basic reference for the fire safety studies. The reasons are varied and can be agreed as in the Q.2. The students are teenagers and they are capable of handling a fire extinguisher or having better understanding about fire safety. Their mental, physical and psychological attributes are at a stable and energetic condition even though they are still developing.
Their working environment is similar to those of earlier educational stages such as primary schools and also similar to those of later stage such as university. It stays as the intermediate stage for the level of education available in most countries or places. Time they spend within the areas is almost 24 hours a day and under supervision by their facilitators or teachers. It keeps the limitation of this fire safety studies to a certain extent which probably makes it easier to be covered and understood before the advancement of studies about fire safety within the same area can be proceed. Therefore, it is suitable to be the basic model or stage for the further research in fire safety in any other educational establishment. It is also agreed on the reasons why the studies are being carried out by the researcher.

Q.5: All members of the Delphi group agreed that the following are the division of building functions within a school compound:— (Refer to Appendix 5.3: Part B)

a. Academic areas deal with theoretical development
b. Living and Accommodation area for resting, food, shelter and health.
c. Sports and spiritual development area
d. Academic area which deals with skills and enterpreneurship development
e. Administration and management area.

The building functions mentioned above can still be divided into smaller and more specific areas or buildings. Sometimes the areas are confined within a building. However, the divisions are divided according to their functions and location within the buildings and areas of the school compound.

Q.6: Once the building functions have been agreed on their merits. Then the importance of the building functions should be established. The Delphi group has given a rank order for the building functions as follows:— (Refer to Appendix 5.3: Part B)
Academic area deals with theoretical development 1st (Essential)
Living and Accommodation area for resting, food, shelter and health. 2nd (Very Important)
Sports and spiritual development area 4th (Important)
Academic area which deals with skills and entrepreneurship development 3rd (Very Important)
Administration and management area 5th (Quite Important)

Table 5.9.5: Building Function Priority

Academic area which deals with the theoretical development is ranked as the priority compared to other building functions because it is the place where most of the children will spend their time while in school.

5.5 PART C: The Priority of Areas Within the Educational Buildings.

<table>
<thead>
<tr>
<th>Areas</th>
<th>Yes=1</th>
<th>No=2</th>
<th>Average</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guard house</td>
<td>80%</td>
<td>20%</td>
<td>1.2</td>
<td>discuss</td>
</tr>
<tr>
<td>Teacher quarters</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Principal's house</td>
<td>90%</td>
<td>10%</td>
<td>1.1</td>
<td>discuss</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>80%</td>
<td>20%</td>
<td>1.2</td>
<td>discuss</td>
</tr>
<tr>
<td>Assembly Hall</td>
<td>90%</td>
<td>10%</td>
<td>1.1</td>
<td>discuss</td>
</tr>
<tr>
<td>Canteen</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Workshop</td>
<td>70%</td>
<td>30%</td>
<td>1.3</td>
<td>discuss</td>
</tr>
<tr>
<td>Laboratory</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Classroom</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Home Science</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Administration</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Staff room</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Computer room</td>
<td>90%</td>
<td>10%</td>
<td>1.1</td>
<td>discuss</td>
</tr>
<tr>
<td>Meeting room</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Technology Media</td>
<td>90%</td>
<td>10%</td>
<td>1.1</td>
<td>discuss</td>
</tr>
<tr>
<td>Library</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Resource centre</td>
<td>80%</td>
<td>20%</td>
<td>1.2</td>
<td>discuss</td>
</tr>
<tr>
<td>Drawing studio</td>
<td>90%</td>
<td>10%</td>
<td>1.1</td>
<td>discuss</td>
</tr>
<tr>
<td>Co-operative shop</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Hostel Block</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Prayer Hall</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Reading room</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Pantry</td>
<td>90%</td>
<td>10%</td>
<td>1.1</td>
<td>discuss</td>
</tr>
<tr>
<td>Sick Bay</td>
<td>90%</td>
<td>10%</td>
<td>1.1</td>
<td>discuss</td>
</tr>
<tr>
<td>Dining hall</td>
<td>100%</td>
<td></td>
<td>1.0</td>
<td>agreed</td>
</tr>
<tr>
<td>Kitchen</td>
<td>90%</td>
<td>10%</td>
<td>1.1</td>
<td>discuss</td>
</tr>
<tr>
<td>Washing area</td>
<td>80%</td>
<td>20%</td>
<td>1.2</td>
<td>discuss</td>
</tr>
</tbody>
</table>
Overall, the Delphi Group members did agree that the existence of all the above areas within the boarding school was necessary. Generally, most of the boarding schools involved are sponsored directly by the government and based on science stream education background. However, there is some doubt about the existence of the workshops within the school compound. The reasons are mainly because of the technical syllabus may not be a priority set for the education program of government except for technical schools. However, it is agreed that the workshop area, or building, still exists within the boarding school compound.

The guard house, gymnasium, resource centre and washing area seems to be the areas of a lesser priority within the school. It does mean that the areas such as guard house would make a positive contribution to an increase in safety measures. More facilities for research and a proper separation of the wet and dry spaces would be an advantage. The guard house is important as the earliest and latest source of human supervision about the incoming or outgoing of the population in the school. Gymnasium is a kind of indoor area for the students to take part in a continuation of sports activities. But yet it is not an essential building area within the school unless they have the money to build one. The following are the areas which are likely to exist within any school, particularly the boarding schools in Malaysia. They are being divided into 3 categories according to the opinion of the Delphi group: (Refer to Appendix 5.4: Part C)

**A) Primary Areas (The areas which has been agreed 100%)**

Teacher quarters : Teachers are likely having dual function one as a teacher and the other one as a hostel warden.

Canteen : Almost every school does have a canteen provided.

Laboratory : It is an essential building area within the school where science subjects being taught.

Classroom : It is the highest priority area that must be considered for a school.

Home Science : It is an area for learning household works which do involve some cooking and ironing etc. It is an essential subject to be taught for the school girls while the schools boys are taught in the workshop.

Administrative office: This is the most important area for all of the occupants or visitors to refer for any enquiry during the working office hours.
Staff room: It is the area where most of the teaching staff is based during intervals in teaching while in the school. They normally have all their teaching aids such as books, student assignments and even personal belongings are kept while in the school compound. This area is used for discussion among the teachers, for short breaks and for the preparation of the education syllabus.

Conference or meeting room: Most of the secondary boarding schools in Malaysia seem to be having these areas provided and besides conducting seminars, talks and conferences to the staff and students, it is also used for other purposes such as group meetings at all levels and are usually fit for a small but reasonable number of people between 30 to 50.

Library: Is the most important source of references and information on various subjects. It is usually used by all the occupants of a school and there are all sorts of collections within the library.

Co-operative shop: It is becoming an essential part of the school area as they found that the shop creates better facilities in providing the education needs and works as part of extra CO-curriculum activities for the students. It also creates extra income for the school.

Hostel Block: It is an essential part of buildings within any boarding schools. It is meant specifically for living accommodation.

Prayer hall: Can be a necessity particularly involving the spiritual development by a proper teacher or priest. It can be a form of converted dormitory or a classroom size and also in the form of a separate building such as a mosque.

Reading room: It is an important area where students can concentrate on their revision and managing the school work that needs extra hours beyond the normal schedule.

Dining hall: An important area for food and must be included as an essential area within the school. Most of the boarding schools selected are provided with a common dining hall where food is served.

Primary areas are considered to be the essential parts of a school building. However, the rest of the areas mentioned above are considered useful as well as the secondary and tertiary areas, only if the school has no financial problems or other restrictions in constructing them.

B) Secondary Areas (The areas which has been agreed 90%)

Principal's/Deputy House: It can be built within the school compound or else the headmaster/deputy will be travelling to the school everyday. However, for the boarding schools involved with these studies, the
headmaster's/ deputy's house is built within the school compound for easier supervision.

Assembly hall: Most schools are now provided with an assembly hall but if it doesn't have one than the function for any kind of major assembly for the students will be the open field.

Computer room: Mostly all schools are now provided with computer system therefore the need of having a computer room is becoming important. The size of the room is normally depends on the number of computer units available, may be the size of a classroom will be adequate. There is also need for extra supervision.

Technology Media: Is another part of the library or may be separate. Usually, the technology media is a room occupied by the equipment for doing any kind of presentation or recording work. It is supervised by a experienced technician.

Drawing studio: Normal for school where the subject of technical drawing for architectural, building or engineering assignments is taught.

Pantry: It is a small area which being provided by the administration at the staff room or the hostel for the occupants preparing any kind of tea break or supper. Normally having the electric kettle or iron and a wash basin.

Sick Bay: This facilities is absent generally but for full-boarding school sponsored by the government, they do have a special area for any sick occupant to be well rested and taken care by a matron or medical attendant if needed. The sick one to be treated, will be isolated from the healthy ones.

Kitchen: No common kitchen for the occupants within the school except for preparing food at the dining hall by the assigned cooks. It is restricted area for the students to enter and special permission is needed before entering the kitchen area.

C) Tertiary Areas (The areas which has been agreed 80%)

Guard House: Not critical but security is also a part of prevention system for any kind of safety procedure. It is acting as a gate keeper to ensure that the occupants within the school boundary are safe from any unpredictable intruders and dangers from outside.

Gymnasium: Depending on the school income. It is usually used to perform sports activities such as weight lifting, gymnastic, and other indoor body work or exercises.

Resource centre: Depending on the availability of the school budget. Other wise the library is good enough and a separate area specifically for resource centre may not be needed. Normally, the source centre acts as a
library having an assistant to help finding more sources and information which is not available in the library.

**Washing Areas**: Only if laundrette is not provided.

**Workshop**: It can be in two different uses, one for the students learning mechanical and industrial subjects and the other is for the school transport workshop.

### Q:2: Agreement on the following areas of classification
(Refer to Appendix 5.4: Part C)

There are about 5 major classification of building areas in boarding secondary school:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Overall Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Academic buildings in term of theoretical development</td>
<td>100%</td>
</tr>
<tr>
<td>(e.g.: classroom, library, computer room, technology media)</td>
<td></td>
</tr>
<tr>
<td>2. Sleeping accommodation mainly for resting, health and food</td>
<td>100%</td>
</tr>
<tr>
<td>(e.g.: Dormitory, warden flat, dining hall, room, canteen)</td>
<td></td>
</tr>
<tr>
<td>3. Sports and spiritual mainly for physical, psychological</td>
<td>80%</td>
</tr>
<tr>
<td>(e.g.: Mosque, gymnasium, stadium/field, assembly hall, courts games)</td>
<td></td>
</tr>
<tr>
<td>4. Academic buildings in term of mental, developmental skills</td>
<td>100%</td>
</tr>
<tr>
<td>(e.g.: Laboratory, home science, workshop, co-operative shop)</td>
<td></td>
</tr>
<tr>
<td>5. Administration and Management</td>
<td>90%</td>
</tr>
<tr>
<td>(e.g.: offices, staff room)</td>
<td></td>
</tr>
</tbody>
</table>

The disagreement of 20% about the sports and spiritual areas classified together is because of the spiritual development involving the religious ceremonies cannot be accepted as a part of body maintenance such as sports and games. However, the dispute can be easily overcome with an explanation of the religious performance which does involve mental and health development especially in terms of Islamic religious perception.

It is understood that the sports and religious activities are two different activities that are performed at two different places. Normally the sports take place in an open area such as in the field, semi-closed stadium or in an enclosed area such as a gymnasium. Whereas the spiritual and religious acts are performed within an indoor area such as a proper hall like a mosque, assembly hall or even a temporary converted gymnasium for an occasional religious ceremony. It is only a one way
change of use, sports areas to religious ceremony. However, most of the sports and spiritual religious areas within a boarding school in Malaysia are very flexible and can be used for other purposes especially to perform a major religious ceremony if a mosque is not available within the school.

5.6 LOSS IMPACT

The main objective of fire safety policy is to save human lives. The consequences of fire can be related to several losses other than human life's such as property, the continuity of mission, the environment and of course the economy. The loss impact may also result in different levels of loss. Therefore, an analysis of the loss impact on any buildings which are going to be the basis of fire safety evaluation studies one of the important steps.

In the loss impact study for schools, two major variable need to be combined (1):

1. The relative loss potential in the context of the operation of the school, and
2. The relevant geographical area.

The combination of the two variables are take into consideration several other factors such as the human or occupants and the properties which contribute towards the continuity of the educational mission. The surrounding environment involving the buildings, community, local development and national and international relationship are also amongst the factors.

5.6.1 Relative Loss Potential (the result or effect of loss manifest)

Most of the outcome will be used in looking at the importance of areas within the same system which only affecting the operation of the occupants. The loss impact measures that has been chosen are divided into 7 categories:

a) TRIVIAL Causes slight changes in a particular area or room such as no breakdown in the operation of the school probably by a quick replacement. (i.e.:
A fire in the rubbish bin. The particular group missed out one period of class, about half an hour)

b) NUISANCE Causes minimal changes which affect only a specific room or area in such a way as to have minor effects on the operation of the school. (i.e.: Change of the writing board and probably the involved group missed classes for half a day.)

c) IMPORTANT Causes changes which have a significant effect on a particular area or room of the school. (i.e.: One or two areas become dual function such as moving out of a classroom into a library or a laboratory. The original area is not available for a day, or more, for only the particular group)

d) SIGNIFICANT Causes changes to the operation of the areas within the school. (i.e.: More classes have to moved out or change places/locations. Some of the school activities have to be cancelled but not involving the academic sessions or classes. Probably most of the laboratories, assembly hall, gymnasium and library might be used as classrooms. Those areas will be used only during particular time of the day and the main mission of certain areas still can be carried out. Dual mission temporarily.)

e) DISRUPTIVE Causes changes to the mission of the areas, permanently. (i.e.: Using non-academic building such as gymnasium or accommodation and dining hall for the academic purposes. Some academic classes and activities have to be cancelled.)

f) SEVERE Causes closure of the students and staffs spaces for a week or so and probably some students and staff will have to be given holiday until being informed. Building up several temporary buildings to be used particularly by those who will be facing major examinations in case there is no other alternative or other school as replacement.

g) CATASTROPHIC No School. (i.e.: The whole school operation is at halt for more than a month or so.)

Note: The descriptors for such outcomes can be supported by the "power" of the catchment area of interest.

5.6.2 Relevant Geographical Area

The geographical area related to the building concerned are categorised into 5 different levels. Each level has its own strength of relationship to any disasters within the limitation of impact. The effects of the loss impact on to those areas by a particular building is varied according to the relative loss potential. The levels are as follows:-
Individual space
Specialist group (area/room/department)
Local community (town or district)
City or State
National
International.

Overall, the classification of the types of building areas within a school, particularly boarding school has been agreed as follows:- (Refer to Appendix 5.4: Part C)

1. Academic buildings (Theoretical development)

Priority rank by first Delphi Group perception:

a) Classroom 1  
b) Library 1  
c) Computer Room 2  
d) Technology Media 3 

If one of the areas above 100% involved with fire, the loss impact felt by the rest of the areas as perceived by the Delphi Group:

<table>
<thead>
<tr>
<th>Areas 100% Affected By Fire</th>
<th>Priority</th>
<th>Average Impact</th>
<th>Overall Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Classroom effects on i. Library</td>
<td>1</td>
<td>4.3</td>
<td>4</td>
</tr>
<tr>
<td>ii. Comp. Room</td>
<td>2</td>
<td>3.4</td>
<td>3</td>
</tr>
<tr>
<td>iii. Tech. media</td>
<td>3</td>
<td>3.1</td>
<td>3</td>
</tr>
<tr>
<td>b) Library</td>
<td>i. Classroom</td>
<td>1</td>
<td>3.3</td>
</tr>
<tr>
<td>ii. Tech. Media</td>
<td>2</td>
<td>3.1</td>
<td>3</td>
</tr>
<tr>
<td>iii. Comp. Room</td>
<td>3</td>
<td>2.8</td>
<td>3</td>
</tr>
<tr>
<td>c) Computer Room</td>
<td>i. Library</td>
<td>1</td>
<td>3.2</td>
</tr>
<tr>
<td>ii. Tech. Media</td>
<td>2</td>
<td>2.9</td>
<td>3</td>
</tr>
<tr>
<td>iii. Classroom</td>
<td>3</td>
<td>2.3</td>
<td>2</td>
</tr>
<tr>
<td>d) Technology Media</td>
<td>i. Comp. Room</td>
<td>1</td>
<td>3.2</td>
</tr>
<tr>
<td>ii. Classroom</td>
<td>1</td>
<td>3.2</td>
<td>3</td>
</tr>
<tr>
<td>iii. Library</td>
<td>2</td>
<td>3.0</td>
<td>3</td>
</tr>
</tbody>
</table>

Impact is given as:
0 = Not applicable 1 = Trivial 2 = Nuisance 3 = Important 4 = Significant 5 = Disruptive 6 = Severe 7 = Catastrophic.

In the case of emergencies, the priority rank given in the above table can be used to assist or as a reference for the administration to consider which areas are the most suitable to replace the function of the fire affected areas. These are important for the continuation of mission of the areas affected by fire. Normally the consideration is based on the following:-
1. Severity of the fire accident affecting each of the areas.
2. How long can each of the areas function can be delayed?
3. How important is the mission to the whole operation of the education system within the school boundary? (i.e.; the major examination, finishing the teaching syllabus in order to achieve the target of any major education examination or assessment?
4. Does it involved small or large group of people to be allocated?
5. The most suitable and quickest replacement of the areas possible with least disruption to a certain group or the whole system.
6. The safety of the equipment and the comfort of the occupant while being in the refuge areas.
7. The similarity of space functions that possible to reduce the distraction to other areas.
8. With condition that all the similar areas are being affected or involved in fire.

Once the classroom is being affected by fire the best option that the mission of a classroom should take place is in the library, followed by the computer room and technology media room without consideration having any other classroom or areas available from other classification of building type, such as the laboratory and canteen. The impact of losing a classroom means that the classroom function is taken by the library etc. The library has a significant impact of 4, if the classroom is affected by fire or any emergencies in the case of the academic buildings for theoretical development. Whereas the computer room and technology media areas is having an important impact if the rest of the classroom areas being affected and there is a need for more than a single area to be replaced for the continuation of the classroom mission. Of course other options can be from different types of building areas which has been mentioned earlier. However, each of the areas, if they were involved with fire, they do give a different importance and perception to other areas which will be chosen for the replacement of function for short term solution.
The loss impact relationship between the areas can be referred to the following diagram:

<table>
<thead>
<tr>
<th>Recommended Replacement of area in case of fire emergency</th>
<th>Classroom</th>
<th>Library</th>
<th>Computer room</th>
<th>Technology Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>0******</td>
<td>1</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Library</td>
<td>1</td>
<td>0******</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Computer Room</td>
<td>2</td>
<td>3</td>
<td>0******</td>
<td>1</td>
</tr>
<tr>
<td>Technology Media</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0******</td>
</tr>
</tbody>
</table>

Based on X vs. Y

<table>
<thead>
<tr>
<th>Loss Impact In Case of Fire</th>
<th>Classroom</th>
<th>Library</th>
<th>Computer room</th>
<th>Technology Media</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>0******</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Library</td>
<td>4</td>
<td>0******</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Computer Room</td>
<td>3</td>
<td>3</td>
<td>0******</td>
<td>3</td>
</tr>
<tr>
<td>Technology Media</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0******</td>
</tr>
</tbody>
</table>

Based on X vs. Y

After all the considerations and loss impact relationship discussions, the Delphi Group has selected the rank of importance against fire for the areas involved in academic building types for theoretical development in a secondary school is as follows:

<table>
<thead>
<tr>
<th>Building Areas</th>
<th>Rank Of Importance</th>
<th>Overall Impact level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>1</td>
<td>4 very important</td>
</tr>
<tr>
<td>Computer room</td>
<td>2</td>
<td>4 very important</td>
</tr>
<tr>
<td>Library</td>
<td>3</td>
<td>4 very important</td>
</tr>
<tr>
<td>Technology Media</td>
<td>4</td>
<td>3 important</td>
</tr>
</tbody>
</table>

These results are probably suitable only for the same level or less than secondary schools standard and in the case of more improvement has been done to those areas, than the ranking probably must be changed according to the followings-

i. Economy

ii. The property

iii. The frequency of usage of the area

iv. The impact on other missions.

Example: The computer units for an university is more likely to be very expensive, more than the whole computer room in the secondary school. However for a school, the cost of the computers is high, higher than the expenditure for buying the types of technology media equipment to be used for the school level.
The frequency of using those areas are also important because, in the case of emergency, if the area is affected then it will affect other missions as well. No library means that there are difficulties in doing research and gathering of information and it may be more important than a classroom in terms of university standards.

The computer room is a higher rank than a library in a school because of the danger of using electrical systems is more in computer room than in a library or perhaps the equipment within the computer area is more expensive (maintenance, installation and services). Classroom, Library and Computer room are very important areas for the academic buildings in terms of theoretical development and the Technology Media room is only considered important by the Delphi Group members within a school compound.

2. Sleeping Accommodation Buildings (Mainly to Rest, Health and Food.) (Refer to Appendix 5.4: Part C)

Priority rank by first Delphi Group perception:-

a) Dormitory 1
b) Dining Hall 2
c) Warden Flat 3
d) Canteen 4
e) Single room 5

If one of the areas above 100% involved with fire, the loss impact felt by the rest of the areas as perceived by the Delphi Group:

<table>
<thead>
<tr>
<th>Loss Impact In Case of Fire</th>
<th>Dormitory</th>
<th>Dining Hall</th>
<th>Warden flat</th>
<th>Canteen</th>
<th>Single room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory</td>
<td>0********</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Dining hall</td>
<td>4</td>
<td>0********</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Warden flat</td>
<td>2</td>
<td>1</td>
<td>0********</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Canteen</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>0******</td>
<td>1</td>
</tr>
<tr>
<td>Single room</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>0********</td>
</tr>
</tbody>
</table>

Based on X vs. Y

Loss Impact

where:- 0 = Not applicable 1 = Trivial 2 = Nuisance 3 = Important 4 = Significant 5 = Disruptive 6 = Severe 7 = Catastrophic.

<table>
<thead>
<tr>
<th>Recommended Replacement of area in case of fire emergency</th>
<th>Dormitory</th>
<th>Dining Hall</th>
<th>Warden flat</th>
<th>Canteen</th>
<th>Single room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory</td>
<td>0********</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Dining hall</td>
<td>2</td>
<td>0********</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Warden flat</td>
<td>4</td>
<td>4</td>
<td>0********</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Canteen</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>0******</td>
<td>3</td>
</tr>
<tr>
<td>Single room</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>0********</td>
</tr>
</tbody>
</table>

Based on X vs. Y

191
The Delphi Group has selected the rank of importance against fire for the areas involved in sleeping accommodation building types which is mainly for food, health and rest in a boarding secondary school is as follows:-

<table>
<thead>
<tr>
<th>Building Areas</th>
<th>Rank Of Importance</th>
<th>Overall Impact level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory</td>
<td>1</td>
<td>4 very important</td>
</tr>
<tr>
<td>Dining Hall</td>
<td>2</td>
<td>4 very important</td>
</tr>
<tr>
<td>Single room</td>
<td>3</td>
<td>3 important</td>
</tr>
<tr>
<td>Canteen</td>
<td>4</td>
<td>2 quite important</td>
</tr>
<tr>
<td>Warden Flat</td>
<td>5</td>
<td>2 quite important</td>
</tr>
</tbody>
</table>

There is a slight change on the important of the areas regarding their ranking priority.

3. **Sports and Spiritual Buildings (mainly for physical and psychological development)** (Refer to Appendix 5.4: Part C)

Priority rank by the Delphi Group through first perception:-

a) Mosque 1  
b) Gymnasium 2  
c) Assembly Hall 3  
d) Courts Games 4  
e) Stadium / Field 5

This ranking priority is based on the areas which are mostly in need of a serious consideration against fire emergencies. If one of the areas above 100% involved with fire, the loss impact felt by the rest of the areas as perceived by the Delphi Group is given below:

<table>
<thead>
<tr>
<th>Loss Impact In Case of Fire</th>
<th>Gymnasium</th>
<th>Mosque</th>
<th>Stadium or Field</th>
<th>Assembly Hall</th>
<th>Courts Games</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gymnasium</td>
<td>0******</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Mosque</td>
<td>2</td>
<td>0******</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Stadium/Field</td>
<td>4</td>
<td>2</td>
<td>0******</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Assembly hall</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>0******</td>
<td>4</td>
</tr>
<tr>
<td>Courts Games</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0******</td>
</tr>
</tbody>
</table>

Based on X vs. Y

The function of the affected areas can be best substituted by the most prior areas which are suggested by the Delphi Group in the table below:-

<table>
<thead>
<tr>
<th>Recommended Replacement of area in case of fire emergency</th>
<th>Gymnasium</th>
<th>Mosque</th>
<th>Stadium or Field</th>
<th>Assembly Hall</th>
<th>Courts Games</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gymnasium</td>
<td>0******</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Mosque</td>
<td>-</td>
<td>0******</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>Stadium/Field</td>
<td>2</td>
<td>4</td>
<td>0******</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Assembly Hall</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>0******</td>
<td>3</td>
</tr>
<tr>
<td>Courts Games</td>
<td>1</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>0******</td>
</tr>
</tbody>
</table>

Based on X vs. Y
However, the recommended areas still need to be considered in terms of the types of activities that will be take place in those areas. This matter is very important for such a place like the mosque as it does have it's own objective and purpose which suits it's functions and is a respected building for mainly spiritual and religious activities.

The Delphi Group has developed the rank of importance against fire for the areas involved with sports and spiritual buildings which is mainly for the physical and psychological development of the students. In a full-board secondary school is as follows:-

<table>
<thead>
<tr>
<th>Building Areas</th>
<th>Rank Of Importance</th>
<th>Overall Impact level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosque</td>
<td>1</td>
<td>4 very important</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>2</td>
<td>4 very important</td>
</tr>
<tr>
<td>Assembly hall</td>
<td>2</td>
<td>4 very important</td>
</tr>
<tr>
<td>Stadium/ Field</td>
<td>3</td>
<td>3 important</td>
</tr>
<tr>
<td>Courts' Games</td>
<td>4</td>
<td>2 quite important</td>
</tr>
</tbody>
</table>

The gymnasium should be considered the priority in terms of sports activities. Where as the mosque should remain by itself as it does become involved with religious performances which are totally different activities to sports activities.

4. Academic Buildings (in terms of mental and skill development)
(Refer to Appendix 5.4: Part C)

Priority rank by the Delphi Group through first perception:-

a) Laboratory 1
b) Workshop 2
c) Home Science 3
d) Agricultural Science 4
e) Co-operative shop 5

This ranking priority is based on the areas which are mostly in need of a serious consideration against fire emergencies. If one of the areas above 100% involved with fire, the loss impact felt by the rest of the areas as perceived by the Delphi Group is given below:

<table>
<thead>
<tr>
<th>Loss Impact In Case of Fire</th>
<th>Laboratory</th>
<th>Workshop</th>
<th>Home Science</th>
<th>Agricultural Science</th>
<th>Co-operative Shop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td>0******</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Workshop</td>
<td>5</td>
<td>0******</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Home Science</td>
<td>4</td>
<td>3</td>
<td>0******</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>0******</td>
<td>2</td>
</tr>
<tr>
<td>Co-operative shop</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>0******</td>
</tr>
</tbody>
</table>

Based on X vs. Y

193
The function of the affected areas can be best substituted by the most prior areas which are suggested by the Delphi Group in the table below:-

<table>
<thead>
<tr>
<th>Recommended Replacement of area in case of fire emergency</th>
<th>Laboratory</th>
<th>Workshop</th>
<th>Home Science</th>
<th>Agricultural Science</th>
<th>Co-operative Shop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td>0********</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Workshop</td>
<td>1</td>
<td></td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Home Science</td>
<td>2</td>
<td>3</td>
<td>0********</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>0********</td>
<td>2</td>
</tr>
<tr>
<td>Co-operative shop</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>0********</td>
</tr>
</tbody>
</table>

However, the recommended areas still need to be considered in terms of the types of activities that will be taken place in those areas. It is very important for such a place like the laboratory compared with the rest of the areas, it does have its own purpose and objective which suits it functions as it represent the place for the research and experimental work to be carried out. Therefore, in actual situation, the laboratory should not be used to replace any of the above areas mission because it is dangerous to carry out other functions such as home science, workshop and shopwork in the laboratory. These is because of the nature of the work to be carried is also dangerous (producing sparks, using naked flame) and the quantity of chemicals which exist within the area will need a very close supervision. So there are of course some restrictions for the workshop mission to be done within the laboratory vice versa.

The Delphi Group has selected the rank of importance against fire for the areas involved with academic building which deals with mental and skill development of the students are as follows:-

<table>
<thead>
<tr>
<th>Building Areas</th>
<th>Rank Of Importance</th>
<th>Overall Impact level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td>1</td>
<td>4 very important</td>
</tr>
<tr>
<td>Workshop</td>
<td>2</td>
<td>3 important</td>
</tr>
<tr>
<td>Home Science</td>
<td>3</td>
<td>3 important</td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>4</td>
<td>3 important</td>
</tr>
<tr>
<td>Co-operative shop</td>
<td>5</td>
<td>2 quite important</td>
</tr>
</tbody>
</table>

where: 0 = not applicable 1 = not important 2 = quite important
3 = important 4 = very important 5 = essential.
5. **Administration and Management** (Refer to Appendix 5.4: Part C)

Priority rank by the Delphi Group through first perception:-

a) General Office  1  
b) Staff room  2  

This ranking priority is based on the areas which are mostly in need of a serious consideration against fire emergencies. If one of the areas above 100% involved with fire, the loss impact felt by the rest of the areas as perceived by the Delphi Group is given below:

<table>
<thead>
<tr>
<th>Loss Impact In Case of Fire</th>
<th>General Office</th>
<th>Staff room</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Office</td>
<td>0********</td>
<td>5</td>
</tr>
<tr>
<td>Staff room</td>
<td>5</td>
<td>0********</td>
</tr>
</tbody>
</table>

Based on X vs. Y

where:- 0 = Not applicable  1 = Trivial  2 = Nuisance  3 = Important  4 = Significant  5 = Disruptive  6 = Severe  7 = Catastrophic.

The function of the affected areas can be best substituted by the most prior areas which are suggested by the Delphi Group in the table below:-

<table>
<thead>
<tr>
<th>Recommended Replacement of area in case of fire emergency</th>
<th>General Office</th>
<th>Staff room</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Office</td>
<td>0********</td>
<td>2</td>
</tr>
<tr>
<td>Staff room</td>
<td>1</td>
<td>0********</td>
</tr>
</tbody>
</table>

Based on X vs. Y

The Delphi Group has selected the rank of importance against fire for the areas involved with administration and management of the students in a boarding secondary school is as follows:-

<table>
<thead>
<tr>
<th>Building Areas</th>
<th>Rank Of Importance</th>
<th>Overall Impact level</th>
</tr>
</thead>
<tbody>
<tr>
<td>General office</td>
<td>1</td>
<td>4 very important</td>
</tr>
<tr>
<td>Staff room</td>
<td>2</td>
<td>3 important</td>
</tr>
</tbody>
</table>

where: 0 = not applicable  1 = not important  2 = quite important  3 = important  4 = very important  5 = essential.
5.7 PART D: IDENTIFICATION OF FIRE RISK, FIRE THREAT, SOURCE OF IGNITION AND SOURCE OF FUELS.

5.7.1 BUILDING OCCUPANCY (Refer to Appendix 5.5)

Q:1 Agreement On the Educational Establishment Occupancy (based in Malaysia Secondary Boarding School)

<table>
<thead>
<tr>
<th>Types of Occupancy</th>
<th>Yes = 1</th>
<th>No = 2</th>
<th>Overall Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>100 %</td>
<td></td>
<td>o.k</td>
</tr>
<tr>
<td>Teachers/ Supervisors / Technicians / Lab. Asst.</td>
<td>100 %</td>
<td></td>
<td>o.k</td>
</tr>
<tr>
<td>Principal/ General Administration Staff</td>
<td>100%</td>
<td></td>
<td>o.k</td>
</tr>
<tr>
<td>Warden</td>
<td>100%</td>
<td></td>
<td>o.k</td>
</tr>
<tr>
<td>General Staffs (cook/ cleaner/ gardener/ Guard)</td>
<td>90 %</td>
<td>10 %</td>
<td>discuss</td>
</tr>
<tr>
<td>Visitors</td>
<td>80 %</td>
<td>20 %</td>
<td>discuss</td>
</tr>
</tbody>
</table>

The occupants that work within the school grounds are the students, teaching staffs, laboratory supervisors and assistants, technicians, the school principal, administrative officers and hostel warden. However, the general staff, such as the cook, cleaner, gardener and visitor are not fully accepted by the Delphi group members to be included in the school occupancy list. The disagreement only involved 10 % to 20 % and the argument can be explained as follows:-

a) The general staff only exist in a full residential school where there is no self catering accommodation involved. Food is provided and prepared by food catering contractors which are selected by the Ministry of Education through competitive bids. Even though they did not stay within the school ground and the time spent working in those areas (kitchen and dining halls, school buildings, hostels and school landscape) is long enough to consider them as part of the secondary school occupants. An exception can be given to those of ordinary daily secondary schools without living accommodation for students. Yet the guard, gardener and cleaner are likely to be around in most schools particularly the full residential school for security reasons and maintenance work.

b) About the visitors, almost every school will be visited by outsiders such as the public community, student's parents or guardians, students from other schools
during certain events organised by the school itself, the Ministry of Education officers and others. Emergencies can always be with or without having any visitors within the school grounds. The loss impact would be worse if an emergency happens while visitors are in the school. Contractors doing any repair works based on contracts, also can be considered as visitors also.

Therefore, the general staffs and visitors should also be considered as part of the educational establishment occupancy list of the secondary school.

The agreed list of the secondary boarding school occupancy:-

1. Students
2. Teachers / Supervisors / Technicians / Laboratory Assistants
3. Warden
4. Principal / General Administrative Staff
5. General Workers (cooks, cleaner, gardeners, guards)
6. Visitors

5.7.2 Q:2 Occupants Who Are Likely To Be Involved With Fire Emergency Within Area

<table>
<thead>
<tr>
<th>Areas Within The School Boundary</th>
<th>Students</th>
<th>Teachers / Staff</th>
<th>Principal / Administration</th>
<th>General Workers</th>
<th>Visitors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>4.5</td>
<td>4.3</td>
<td>2.6</td>
<td>1.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Library</td>
<td>4.9</td>
<td>3.8</td>
<td>3.0</td>
<td>2.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Computer Room</td>
<td>4.9</td>
<td>4.5</td>
<td>3.0</td>
<td>2.0</td>
<td>0.9</td>
</tr>
<tr>
<td>Technology Media</td>
<td>4.5</td>
<td>4.1</td>
<td>3.0</td>
<td>1.5</td>
<td>1.0</td>
</tr>
<tr>
<td>Overall Involvement</td>
<td>4.70</td>
<td>4.20</td>
<td>2.90</td>
<td>1.78</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>most likely</td>
<td>very likely</td>
<td>likely</td>
<td>q. likely</td>
<td>unlikely</td>
</tr>
<tr>
<td>Laboratory</td>
<td>4.7</td>
<td>4.3</td>
<td>2.0</td>
<td>1.4</td>
<td>0.9</td>
</tr>
<tr>
<td>Workshop</td>
<td>4.3</td>
<td>4.2</td>
<td>2.1</td>
<td>1.5</td>
<td>0.8</td>
</tr>
<tr>
<td>Home Science</td>
<td>4.3</td>
<td>3.9</td>
<td>2.1</td>
<td>1.2</td>
<td>0.9</td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>4.2</td>
<td>3.8</td>
<td>2.0</td>
<td>1.6</td>
<td>0.9</td>
</tr>
<tr>
<td>Co-operative shop</td>
<td>4.4</td>
<td>3.2</td>
<td>2.5</td>
<td>2.1</td>
<td>1.4</td>
</tr>
<tr>
<td>Overall Involvement</td>
<td>4.38</td>
<td>3.88</td>
<td>2.14</td>
<td>1.56</td>
<td>0.98</td>
</tr>
<tr>
<td></td>
<td>very likely</td>
<td>very likely</td>
<td>quite likely</td>
<td>q. likely</td>
<td>unlikely</td>
</tr>
<tr>
<td>Offices</td>
<td>2.7</td>
<td>4.3</td>
<td>4.3</td>
<td>2.9</td>
<td>1.6</td>
</tr>
<tr>
<td>Staff room</td>
<td>2.2</td>
<td>4.6</td>
<td>2.9</td>
<td>2.4</td>
<td>1.2</td>
</tr>
<tr>
<td>Overall Involvement</td>
<td>2.45</td>
<td>4.45</td>
<td>3.60</td>
<td>2.65</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>quite likely</td>
<td>most likely</td>
<td>very likely</td>
<td>likely</td>
<td>unlikely</td>
</tr>
</tbody>
</table>
The above table shows the likelihood of the occupants being involved in a fire emergency while being within the school boundary during the school operating period of 24 hours, throughout the year. The results can help the administration to determine the probability of the presence of the occupants within the school boundary. Besides, for each of the areas, we can see how often the areas are being used by type of occupants. This will probably assist in designing fire safety procedures and training courses by referring to the types of user for the particular areas. The degree of likelihood of involvement by the occupants within those areas show that the vulnerability of the area against fire emergencies. Then fire safety priority can be given to the area where it is most needed. The administration can get a rough idea on how to tackle the various occupants on fire safety matters and allocate responsibility to certain individuals to assist during any emergencies particularly during fire accidents.

5.7.2.1 Agreement On The Warden Task

It is about 90% of the Delphi Group members agreed that in most cases, the job of a warden is normally taken by a teacher in the same school. However, it is agreed also that to be safe and have more security or supervision, is best to have a person
in charge of the whole accommodation, buildings and the activities within it a proper warden(s). Therefore, more time can be given to look after the safety of the students while being in the accommodation premises. However the help from the teaching staff is needed to assist with the job of a warden of the school hostels.

The next question, what is needed to operate a secondary boarding school ?:-

<table>
<thead>
<tr>
<th>Residential School Occupants</th>
<th>1 = Yes</th>
<th>2 = No</th>
<th>Overall Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>School Children / Students</td>
<td>90 %</td>
<td>10 %</td>
<td>2</td>
</tr>
<tr>
<td>Teachers</td>
<td>100 %</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Principal</td>
<td>90 %</td>
<td>10 %</td>
<td>2</td>
</tr>
<tr>
<td>Hostel warden</td>
<td>60 %</td>
<td>40 %</td>
<td>4</td>
</tr>
<tr>
<td>General Worker</td>
<td>80 %</td>
<td>20 %</td>
<td>3</td>
</tr>
<tr>
<td>Administration Officer</td>
<td>90 %</td>
<td>10 %</td>
<td>2</td>
</tr>
</tbody>
</table>

The operation of a school must consists of the following requirement in order to run the mission successfully. The above table shows the following:-

a)  First, the teaching staffs must be available and followed by a group of students.

b) Second, if the school population including students are large in number and the school establishment is big then a principal and an administrative officer are needed to ensure the running of the school is carried properly according to educational objectives.

c) Third, in order to maintain the condition of the educational buildings and environment, general worker(s) is/are needed. The overall school environment must be supervised, kept tidy and hygienic for the better perception of the school by the public especially the occupants themselves so that the educational operation sustained and having positive development as long as it exist.

d) Fourth, if the school does have a number of students living within the school hostels and so called boarding school, than hostel warden is needed to supervise and maintain the hostel buildings and the activities within it.
5.7.3 Q:3 Vulnerability of the occupancy towards fire to the eyes of the public

<table>
<thead>
<tr>
<th>Occupancy Categories</th>
<th>Average</th>
<th>Rank of Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students</td>
<td>1.8</td>
<td>1</td>
</tr>
<tr>
<td>Teachers / Staff</td>
<td>2.1</td>
<td>2</td>
</tr>
<tr>
<td>Hostel Warden</td>
<td>2.7</td>
<td>4</td>
</tr>
<tr>
<td>Principal / Administrator</td>
<td>2.9</td>
<td>5</td>
</tr>
<tr>
<td>General Workers</td>
<td>2.5</td>
<td>3</td>
</tr>
<tr>
<td>Visitors</td>
<td>3.4</td>
<td>6</td>
</tr>
</tbody>
</table>

where: - 1 = highly priority, 2, 3, 4, and 6 = least priority

The Delphi group has been acting on behalf of the public to give their perception about the vulnerability of the school occupants towards danger of fire particularly at their work place. It has been agreed that the vulnerability priority is given to the students as they are still young and in need of supervision especially when undertaking activities involving electricity, chemicals or even naked flame in laboratory work. The teachers came second as they normally involved with the same activities that students might be doing. Normally, the teachers are more aware about their environment and their number are far less than the students. The general workers come third followed by the hostel warden, principal or the headmaster and finally the visitors. Among the considerations are:-

i. The nature of their work and activities they involved in, i.e.: the availability of the chemical substance, gaseous, naked flame, combustible materials and fuels.

ii. Their age, knowledge, experience and responsibility within the boundary.

iii. Their number in person within the same area where the activities took place.

iv. The duration of time and frequency that they spend dealing with the activities or being within the school boundary.
5.7.4 Q:4 Rank the capability of the occupants to evacuate during any fire emergency.

<table>
<thead>
<tr>
<th>Occupancy Categories</th>
<th>Average</th>
<th>Overall</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Physical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong</td>
<td>-0.6</td>
<td>-1</td>
<td>normal</td>
</tr>
<tr>
<td>Weak (Asthmatic etc.)</td>
<td>-3.5</td>
<td>-4</td>
<td>more difficult</td>
</tr>
<tr>
<td>Strong / Handicapped</td>
<td>-2.7</td>
<td>-3</td>
<td>hard</td>
</tr>
<tr>
<td>Weak / Handicapped</td>
<td>-4.1</td>
<td>-4</td>
<td>more difficult</td>
</tr>
<tr>
<td>Blind</td>
<td>-4.7</td>
<td>-5</td>
<td>very difficult</td>
</tr>
<tr>
<td>Deaf</td>
<td>-3.4</td>
<td>-3</td>
<td>hard</td>
</tr>
<tr>
<td>Normal</td>
<td>-0.7</td>
<td>-1</td>
<td>normal</td>
</tr>
<tr>
<td>b. Physiological</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fat / Big</td>
<td>-2.6</td>
<td>-3</td>
<td>hard</td>
</tr>
<tr>
<td>Thin / Big or Tall</td>
<td>-1.6</td>
<td>-2</td>
<td>quite hard</td>
</tr>
<tr>
<td>Fat / Small</td>
<td>-2.0</td>
<td>-2</td>
<td>quite hard</td>
</tr>
<tr>
<td>Thin / Small</td>
<td>-1.3</td>
<td>-1</td>
<td>normal</td>
</tr>
<tr>
<td>Normal</td>
<td>-0.9</td>
<td>-1</td>
<td>normal</td>
</tr>
<tr>
<td>c. Psychological</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress</td>
<td>-2.7</td>
<td>-3</td>
<td>hard</td>
</tr>
<tr>
<td>Mentally Retarded</td>
<td>-4.3</td>
<td>-4</td>
<td>more difficult</td>
</tr>
<tr>
<td>Normal</td>
<td>-0.8</td>
<td>-1</td>
<td>normal</td>
</tr>
</tbody>
</table>

Table 5.9.6a: Q.4:: Rank Order of The Occupants Capability to Evacuate During Fire Emergency

where: 0 = very easy  -1 = normal  -2 = quite/slightly hard
-3 = hard  -4 = more difficult  -5 = very difficult

The capability of the occupants to evacuate a building can be measured using descriptive method by simply giving certain points to a particular individual. The points are given by the Delphi Group members for the emergency evacuation procedure to be used by the administrative officer when deciding whether to provide extra facilities for certain individuals or not. Individual capabilities mainly depend on three factors:

a. Physical
b. Physiological
c. Psychological

By referring to the Table 5.9.6:Q.4 above, a method to calculate the evacuation capabilities of each individual can be developed. A compromise between the fire engineering techniques to be installed and the capabilities of the occupants may result in saving the cost of certain fire safety system(s) which is not necessary in the
building. However, the details of the evaluation process is good enough to show the condition of an area with the type of occupants available. This enables decisions on which areas need more attention than other areas.

The physical, physiological and psychological characteristics of the occupants did show that certain requirements of fire safety in a building area should take into account the condition of the occupants. Psychological and physical characteristics of the occupants show a greater concern for fire safety engineers and administrators. The Q4 table is useful for designing the evacuation and escape route facilities and procedures.

5.7.5 Q:5 The Types Of Fire Threat Within Areas

<table>
<thead>
<tr>
<th>Areas Within Buildings</th>
<th>Electrical Equipment</th>
<th>Gases Supply</th>
<th>Chemical Substance</th>
<th>Combustible Materials</th>
<th>Combustible Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>4.0</td>
<td>1.3</td>
<td>1.1</td>
<td>3.9</td>
<td>3.3</td>
</tr>
<tr>
<td>Library</td>
<td>4.0</td>
<td>1.6</td>
<td>0.9</td>
<td>4.3</td>
<td>3.3</td>
</tr>
<tr>
<td>Computer Room</td>
<td>4.4</td>
<td>1.3</td>
<td>0.8</td>
<td>3.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Technology Media</td>
<td>4.3</td>
<td>1.6</td>
<td>1.1</td>
<td>3.5</td>
<td>3.2</td>
</tr>
<tr>
<td>Overall Average</td>
<td>4.2</td>
<td>1.5</td>
<td>1.0</td>
<td>3.9</td>
<td>3.3</td>
</tr>
<tr>
<td>Average</td>
<td>very likely</td>
<td>quite likely</td>
<td>unlikely</td>
<td>very likely</td>
<td>likely</td>
</tr>
<tr>
<td>Laboratory</td>
<td>4.1</td>
<td>4.5</td>
<td>4.3</td>
<td>4.2</td>
<td>3.3</td>
</tr>
<tr>
<td>Workshop</td>
<td>4.3</td>
<td>4.3</td>
<td>3.6</td>
<td>4.2</td>
<td>3.7</td>
</tr>
<tr>
<td>Home Science</td>
<td>4.4</td>
<td>4.2</td>
<td>3.1</td>
<td>3.9</td>
<td>3.2</td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>3.1</td>
<td>2.5</td>
<td>3.2</td>
<td>3.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Co-operative shop</td>
<td>4.0</td>
<td>0.9</td>
<td>1.4</td>
<td>3.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Overall Average</td>
<td>4.0</td>
<td>3.3</td>
<td>3.1</td>
<td>3.9</td>
<td>3.4</td>
</tr>
<tr>
<td>Average</td>
<td>very likely</td>
<td>likely</td>
<td>likely</td>
<td>very likely</td>
<td>likely</td>
</tr>
<tr>
<td>Offices</td>
<td>3.9</td>
<td>1.2</td>
<td>0.7</td>
<td>3.7</td>
<td>3.4</td>
</tr>
<tr>
<td>Staff room</td>
<td>3.8</td>
<td>1.2</td>
<td>0.7</td>
<td>3.8</td>
<td>3.3</td>
</tr>
<tr>
<td>Overall Average</td>
<td>3.9</td>
<td>1.2</td>
<td>0.7</td>
<td>3.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Average</td>
<td>very likely</td>
<td>unlikely</td>
<td>unlikely</td>
<td>very likely</td>
<td>likely</td>
</tr>
</tbody>
</table>

(Continue)
### Areas Within Buildings

<table>
<thead>
<tr>
<th>Areas Within Buildings</th>
<th>Electrical Equipment</th>
<th>Gases Supply</th>
<th>Chemical Substance</th>
<th>Combustible Materials</th>
<th>Combustible Structures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory</td>
<td>4.1</td>
<td>1.3</td>
<td>0.8</td>
<td>3.9</td>
<td>3.3</td>
</tr>
<tr>
<td>Warden flat</td>
<td>3.9</td>
<td>2.3</td>
<td>1.0</td>
<td>3.9</td>
<td>3.1</td>
</tr>
<tr>
<td>Dining Hall</td>
<td>4.0</td>
<td>2.9</td>
<td>0.8</td>
<td>3.5</td>
<td>3.1</td>
</tr>
<tr>
<td>Single Room</td>
<td>3.8</td>
<td>0.7</td>
<td>0.7</td>
<td>3.6</td>
<td>2.8</td>
</tr>
<tr>
<td>Canteen</td>
<td>3.8</td>
<td>3.5</td>
<td>1.2</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td><strong>Overall Average</strong></td>
<td><strong>3.9</strong></td>
<td><strong>2.1</strong></td>
<td><strong>0.9</strong></td>
<td><strong>3.7</strong></td>
<td><strong>3.1</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Areas Within Buildings</th>
<th>very likely</th>
<th>quite likely</th>
<th>unlikely</th>
<th>very likely</th>
<th>likely</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosque/Prayer Hall</td>
<td>3.7</td>
<td>1.1</td>
<td>0.6</td>
<td>3.4</td>
<td>3.1</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>2.9</td>
<td>0.6</td>
<td>0.6</td>
<td>3.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Stadium/Field</td>
<td>2.7</td>
<td>0.7</td>
<td>0.5</td>
<td>2.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Assembly Hall</td>
<td>3.2</td>
<td>0.7</td>
<td>0.4</td>
<td>3.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Courts games</td>
<td>2.8</td>
<td>0.6</td>
<td>0.3</td>
<td>2.4</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Overall Average</strong></td>
<td><strong>3.1</strong></td>
<td><strong>0.7</strong></td>
<td><strong>0.5</strong></td>
<td><strong>3.0</strong></td>
<td><strong>2.9</strong></td>
</tr>
</tbody>
</table>

Table: 5.9.6b:Q.5:The Types Of Fire Threat Within Areas

where: 0 = not applicable  1 = unlikely  2 = quite likely  3 = likely  4 = very likely  5 = most likely

The overall average given in the table above can be used as a general perception of all the areas involved within the same category. However, to be more specific the individual boxes can explain the probability of each area relationship with the types of fire threat that are possible. For example, if we checked on the types of fire threat within an office. In this case the general office of the boarding school, not looking at the table, it would be seen that there will be a lot of electrical equipment, combustible materials such as papers or record books and also combustible structures for example the partitions and furniture. The office is unlikely to have gas supply or chemical substance within it's boundary. But if the points given is not zero then there is a possibility that a small amount of chemical substances may occur in the office, such as the toner, or other photocopy machine liquid, which needs to be used for its continuation of operation.
### 5.7.6 Q:6 The Rank Order for the Common Source(s) Of Fire Accident Within The School Boundary.

<table>
<thead>
<tr>
<th>Source(s) of Ignition</th>
<th>Average</th>
<th>Overall Result</th>
<th>Rank Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrical Equipment Faulty</td>
<td>4.30</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Human Error</td>
<td>4.10</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Arson / Deliberate Action</td>
<td>2.89</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>Natural Disaster</td>
<td>1.90</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Bad Maintenance On Building</td>
<td>3.50</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Fire Spread From External Activities</td>
<td>2.80</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Combustible Structure Materials</td>
<td>3.20</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Candle Light</td>
<td>2.80</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>Laboratory Activities</td>
<td>3.60</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Smoking Cigarettes</td>
<td>3.60</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Fireworks</td>
<td>2.90</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Mosquito coils/rings</td>
<td>3.50</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Oil Lamp</td>
<td>2.40</td>
<td>2</td>
<td>9</td>
</tr>
</tbody>
</table>

Table 5.9.6c:Q.6: The Rank Order for the Common Source(s) Of Fire Accident Within The School Boundary

where: - 0 = not applicable 1 = unlikely 2 = quite likely
3 = likely 4 = very likely 5 = most likely

The likelihood of the source(s) of ignition can be categorised as follows:-

**A. Very Likely Category**

i. Electrical equipment fault

ii. Human error

iii. Laboratory activities

iv. Smoking cigarettes

v. Bad building maintenance

vi. Mosquito coils/rings

**B. Likely Category**

i. Combustible Structural Materials

ii. Fireworks

iii. Arson / Deliberate Action

iv. Candle light

v. Fire spread from external activities

**C. Quite Likely Category**

i. Oil Lamp

ii. Natural Disaster

This rank for the common source(s) of fire accident within the boarding school can be used to identify hazardous locations.
5.8 PART E: FIRE SAFETY POLICY AND OBJECTIVES FOR THE EDUCATIONAL ESTABLISHMENT (RESIDENTIAL SCHOOL)

5.8.1 LIFE SAFETY (Refer to Appendix 5.6)

<table>
<thead>
<tr>
<th>Occupant</th>
<th>Average</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Mature students &amp; normal</td>
<td>0.90</td>
<td>1</td>
</tr>
<tr>
<td>b) Child and normal</td>
<td>-0.10</td>
<td>0</td>
</tr>
<tr>
<td>c) Aged and normal</td>
<td>-0.10</td>
<td>0</td>
</tr>
</tbody>
</table>

where: 1 = highly capable  0 = capable  -1 = less capable

The types of occupants within a school includes mature students, children and the aged. Their capability to escape within a short time and to reach the safe areas outside the building are those of mature, normal student occupants. They are highly capable and are followed closely by the children and the older people.

<table>
<thead>
<tr>
<th>Average</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Basement</td>
<td>-0.33</td>
</tr>
<tr>
<td>b) Ground floor</td>
<td>1.00</td>
</tr>
<tr>
<td>c) 1st, floor</td>
<td>0.20</td>
</tr>
<tr>
<td>d) 2nd. Floor</td>
<td>-0.90</td>
</tr>
<tr>
<td>e) 3rd. Floor</td>
<td>-1.80</td>
</tr>
<tr>
<td>f) Top Floor</td>
<td>-2.40</td>
</tr>
</tbody>
</table>

where; 1 = very easy  0 = easy  -1 = quite difficult  -2 = very difficult  -3 = extremely difficult

According to the ease of evacuation the areas of a multi-storey building by the occupants in a given scenario, it has been agreed that evacuation from different storey levels in a building will affect the rank order of evacuation difficulties. The ground floor will be the easiest one to evacuate. First floor and basement of buildings are considered to be easy in evacuation also but as the number of floors increase the building evacuation action will be more difficult because of the need to travel down (or up) more flights of stairs. However, in the existing school situation in Malaysia, there are very few buildings with a basement but it could be relevant in the future when the land constraint becomes more important.

In the case of a fire emergency within the school boundary agreements within the Delphi group on the scenarios are as follows:-
There are several things to be considered in the evacuation process. The safety of the occupants of the building is the main purpose but in order to ensure that the evacuation process will be successful, the building structure must be stable and strong. The components of a building structure that will assist the occupants to evacuate safely are as follows:-

<table>
<thead>
<tr>
<th>Building structures</th>
<th>Overall Average</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Fire resistance door</td>
<td>1.00</td>
<td>Yes</td>
</tr>
<tr>
<td>b) Fire resistance wall(covered)</td>
<td>1.00</td>
<td>Yes</td>
</tr>
<tr>
<td>c) Corridors(horizontal movement)</td>
<td>1.11</td>
<td>Yes</td>
</tr>
<tr>
<td>d) Staircases(vertical movement)</td>
<td>1.10</td>
<td>Yes</td>
</tr>
</tbody>
</table>

where: 1 = Yes and 2 = No
The fire resistant doors and walls are important for the time for fire or smoke to spread within a protected area. Corridors and staircases are clearly to ease the movement of the building occupants in a directional way either horizontally or vertically into and within the escape route(s) or the exit route to a safe place outside the building.

The disabled provision for evacuation process within the educational buildings are agreed to be the wheel chair or push chair, stretcher, ramp, fire lift and personal assistant. In the context of the school buildings in Malaysia, fire lifts do not exist at all because height of the buildings are not more than 4 storeys.

<table>
<thead>
<tr>
<th>Disabled Facilities Required</th>
<th>Overall</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Wheel chair</td>
<td>1.00</td>
<td>Yes</td>
</tr>
<tr>
<td>b) Stretcher</td>
<td>1.00</td>
<td>Yes</td>
</tr>
<tr>
<td>c) Ramp</td>
<td>1.10</td>
<td>Yes</td>
</tr>
<tr>
<td>d) Fire Lift</td>
<td>1.20</td>
<td>Yes</td>
</tr>
<tr>
<td>e) Personal assistant</td>
<td>1.10</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: 1 = yes and 2 = No.

The importance of life safety to the Fire Policy was considered to be essential by the Delphi group. This parallels with most of the fire policy stated by regulations that apply to buildings, industries and workplaces. Therefore, the authority and designers should give high priority to the safety of students, teachers and other educational occupants.

If a fire scenario at school causes loss of life, how would you rank the importance of life safety?

<table>
<thead>
<tr>
<th>Life Safety to Fire Policy</th>
<th>Overall</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.80</td>
<td>Essential</td>
</tr>
</tbody>
</table>

where:- 0 = not applicable  1 = not important  2 = quite important  3 = important  4 = very important  5 = essential

5.8.2 PROPERTY PROTECTION

The overall impact of Property Loss with the Continuation of the school Educational system is considered to be very serious. These involve the teaching and studying appliances, laboratory equipment, furniture and of course the building itself.
However, if only certain areas being affected by fire in an emergency, there will be a
different level of loss impact on the continuity of the education depending on the
severity and location of the fire.

If some part of the school involved with fire, how would you consider the impact of property
loss.

<table>
<thead>
<tr>
<th>Property Loss to Continuity</th>
<th>Overall</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3.90</td>
<td>Very Serious</td>
</tr>
</tbody>
</table>

where:- 0 = not applicable 1 = not serious 2 = quite serious 3 = serious
4 = very serious 5 = vital

In terms of Property Protection, the relationship with the Educational and Fire Policy
is considered to be very important. The Education policy set by the government of
Malaysia is a major topic and a proper way to evaluate the level of loss impact is
through the continuity of the educational process. If delay occurs, the degree of loss
impact will depend on how long each of the affected activities within the
establishment is affected.

If a scenario of fire accident at school causes loss of property (furniture / equipment and
buildings)

<table>
<thead>
<tr>
<th>Rank Property Protection to Policy</th>
<th>Overall</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4.10</td>
<td>Very Important</td>
</tr>
</tbody>
</table>

where:- 0 = not applicable 1 = not important 2 = quite important 3 = important
4 = very important 5 = essential

5.8.3 EDUCATIONAL ENVIRONMENT

The agreement on the following scenario:-

<table>
<thead>
<tr>
<th>The agreement on the following scenario:-</th>
<th>Overall</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>i/ Students need extra comfort within their study or living areas</td>
<td>1.00</td>
<td>Yes</td>
</tr>
<tr>
<td>ii/ Bad odour from surrounding activities can affect students' performance.</td>
<td>1.00</td>
<td>Yes</td>
</tr>
<tr>
<td>iii/ Students concentration can be affected if built nearby motorways offices and factories environment.</td>
<td>1.00</td>
<td>Yes</td>
</tr>
<tr>
<td>iv/ Air and water pollution from the fire accident can affects students.</td>
<td>1.00</td>
<td>Yes</td>
</tr>
<tr>
<td>v/ Fire accidents within the school can change the educational environment.</td>
<td>1.10</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Note: 1 = Yes and 2 = No
About 9 factors which are thought to be relevant within the educational environment in Malaysia are the environmental temperature, good views, air circulation, mobility within space, good odour, acoustic, sunlight, shading and number of students. The relationships between the educational environment required for the particular areas within the school buildings are very important in order to achieve the maximum performance of the students. The environment required by areas are being checked and agreed as represented in Appendix 5.6.

Example of all the relevant building areas and its related environment under consideration are given in Table 5.9.7d: Part E:-

**Building Areas To Good Mobility Within Space:**

<table>
<thead>
<tr>
<th>Education Area</th>
<th>Sum</th>
<th>Result</th>
<th>Sum</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classroom</td>
<td>9.00</td>
<td>y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Library</td>
<td>9.00</td>
<td>y</td>
<td>Dormitory</td>
<td>10.00</td>
</tr>
<tr>
<td>Computer Room</td>
<td>7.00</td>
<td>y</td>
<td>Warden Flat</td>
<td>7.00</td>
</tr>
<tr>
<td>Technology Media</td>
<td>8.00</td>
<td>y</td>
<td>Dining hall</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Single Room</td>
<td>8.00</td>
</tr>
<tr>
<td>Laboratory</td>
<td>9.00</td>
<td>y</td>
<td>Canteen</td>
<td>9.00</td>
</tr>
<tr>
<td>Workshop</td>
<td>7.00</td>
<td>y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Home Science</td>
<td>8.00</td>
<td>y</td>
<td>Public</td>
<td></td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>7.00</td>
<td>y</td>
<td>Mosque/Prayer hall</td>
<td>10.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Gymnasium</td>
<td>8.00</td>
</tr>
<tr>
<td>Co-operative Shop</td>
<td>5.00</td>
<td>n</td>
<td>Stadium/Field</td>
<td>4.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Assembly hall</td>
<td>7.00</td>
</tr>
<tr>
<td>Administration</td>
<td></td>
<td></td>
<td>Courts Games</td>
<td>5.00</td>
</tr>
<tr>
<td>Offices</td>
<td>9.00</td>
<td>y</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Staff room</td>
<td>9.00</td>
<td>y</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.9.7d: Part E: Building Areas To Good Mobility Within Space

From Table 5.9.7d: Part E, circulation or mobility within the co-operative shop is not very important for the occupants to move about because it is usually being catered by one or two person who are on duty at particular time during the school hours. This situation is mainly based in Malaysian schools where the students become members of the co-operative shop and operate the business by themselves with supervision of a trained teacher. The customer normally requests the items to buy over the counter. However, a big co-operative shop run within a university or even in the school the mobility of the customers in the shop must be considered. This is important for any type of emergency particularly in the evacuation process. Security is normally controlled by having a checking counter near to the entrance or exit door.
The importance of mobility within a space is usually related to the comfort level of travelling distance and/or density and the quickest way to escape during emergency.

The table 5.9.7a to 5.9.7i in Appendix 5.6 are all related to the environment which are expected by the educational occupants through the Delphi group perceptions. Basically in all the areas considered, if the “y” are open plan conditions, then most of the environmental requirements are not seriously needed. It only involves the enclosed areas. Each area was allocated with a point if it is considered to be having close relationship with the expected environment where a significant point would be the highest or most contributed by the Delphi group. Therefore, most of the areas in the table where the overall given points is total sum of 5 or less are considered not important to have the particular environment. In Malaysia, the number of students for a classroom is reasonable but over crowding could occur in the near future if no more classrooms are built to accommodate the increasing numbers of students.

The results of the discussion and perceptions can be used by professionals and designers, particularly the architects and government authorities, as reference and decision making in the overall design of school buildings. For example the total number given to each area by the summation of agreement of the Delphi members, can be used as a rank of priority when dealing with the environmental requirement.

In any fire scenario, how would you rank the importance of the Educational Environment in order to achieve:-

<table>
<thead>
<tr>
<th>Overall</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education Environment To Education Policy</td>
<td>3.90</td>
</tr>
</tbody>
</table>

where:- 0 = not applicable  1 = not important  2 = quite important
3 = important  4 = very important  5 = essential.

However, the overall Educational Environment is considered to be very important in order to achieve the Education Policy set by the government and also to fulfil the National Fire Policy.
5.8.4 PUBLIC ANXIETY (PA)

The relationship between the fire accident in a school with the corresponding matters:-

<table>
<thead>
<tr>
<th>Matters</th>
<th>Average</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public concern about school fire safety standard.</td>
<td>1</td>
<td>o.k</td>
</tr>
<tr>
<td>Public will consider about sending their children to that school.</td>
<td>1</td>
<td>o.k</td>
</tr>
<tr>
<td>Politician will be involved.</td>
<td>1</td>
<td>o.k</td>
</tr>
<tr>
<td>Government will have to evaluate the school safety.</td>
<td>1</td>
<td>o.k</td>
</tr>
<tr>
<td>Principal/Head master will be pressured by the community and public</td>
<td>1</td>
<td>discuss</td>
</tr>
<tr>
<td>The government official, administrators and other authority reputation will be affected.</td>
<td>1</td>
<td>o.k</td>
</tr>
<tr>
<td>Involved political and moral values</td>
<td>1</td>
<td>o.k</td>
</tr>
<tr>
<td>Public will questioned about the standard of fire safety at school.</td>
<td>1</td>
<td>discuss</td>
</tr>
<tr>
<td>Public will enquire about Government Budget for fire safety installation</td>
<td>1</td>
<td>discuss</td>
</tr>
</tbody>
</table>

From the table above, fire accidents in schools seem to be very influential and are likely to result in some kind of reaction from the community at local and/or at national level. If the accident involved number of human fatalities the reaction could be swift and powerful. It has been agreed that the public normally will enquire or protest about the standard of the school and probably will not send their children to the same school again if it is found to be unsafe. Other matters that will be given attention, if the school is in a dangerous state, are the political and moral issues. This surely would cause the reputation of government officials, administrators and other authorities to be affected. In certain cases, the public will enquire about the standard of fire safety usage, the allocation of budget and even suggest the blame for the incident falls to government.

In a fire scenario, how would you rank the importance/relationship of the Public Anxiety with the Fire Policy.

**Public Anxiety to Fire Policy** 3.70 very important

where:- 0 = not applicable 1 = not important 2 = quite important 3 = important 4 = very important 5 = essential
The importance or relationship of the Public Anxiety with the Fire Policy is considered to be very important. In many cases, public anxiety could contribute to the implementation of the government Act and Policy for fire safety standards.

5.8.5 ECONOMY

Cost and budget for installation, commission, maintenance and also all other fire safety purposes are very important matters to be considered. How would you rank the importance of economy with the Fire Safety Policy?

| Economy To Fire Policy | 3.80 | very important |

where:- 0 = not applicable 1 = not important 2 = quite important 3 = important 4 = very important 5 = essential

The cost and budget of the construction of the school building are always be the major topic to be considered in order to proceed with the whole process. Without adequate funding, a lot of work will be delayed or halted. This agreement by the Delphi group shows that the administrators and designers need to make their decisions on how to achieve the fire policy based on good value for money particularly for clients or for their own establishment.

Construction Economics is considered to be very important in all aspects of fire safety. Good management and wise spending will also assist in reducing the extras, or the over spending cost, on fire safety systems. It should be possible to incur minimum cost for the required level of fire safety.

5.8.6 FIRE SAFETY OBJECTIVES AND FIRE SAFETY POLICY.

Rank the Priority of The Selected Fire Safety Objectives in terms of Achieving The Fire Safety Policy

<table>
<thead>
<tr>
<th>Fire Safety Objectives</th>
<th>Average</th>
<th>Overall</th>
<th>Priority Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td>4.90</td>
<td>5</td>
<td>1 Top</td>
</tr>
<tr>
<td>Property Protection</td>
<td>3.80</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Educational Mission Continuity</td>
<td>4.10</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Educational Environment</td>
<td>3.60</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Public Anxiety</td>
<td>3.50</td>
<td>4</td>
<td>5 Lowest</td>
</tr>
<tr>
<td>Economy</td>
<td>3.60</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>
The above table shows that first perception by the Delphi members about the rank of priority of the selected fire safety objectives in terms of achieving the fire safety policy for the educational establishment are arranged in order as follows:-

a. Life safety  
b. Education Continuity (mission)  
c. Property protection  
d. Education Environment  
e. Economy  
f. Public Anxiety

However, the rank order of the Fire Safety Objectives will be discussed again at the end of this section.

What is the impact on the following objectives if a fire accidents involving loss of life?

<table>
<thead>
<tr>
<th>Fire Safety Objectives</th>
<th>Average</th>
<th>Overall</th>
<th>Priority Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td>6.60</td>
<td>7</td>
<td>1 Top</td>
</tr>
<tr>
<td>Property Protection</td>
<td>4.70</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Educational Mission Continuity</td>
<td>5.10</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Educational Environment</td>
<td>4.70</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Public Anxiety</td>
<td>5.00</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Economy</td>
<td>4.40</td>
<td>4</td>
<td>6 Lowest</td>
</tr>
</tbody>
</table>

In almost any accident, if a human life is involved either caused fatality or not, the priority concern of the fire safety objectives will always be the Life Safety and followed by the Education Continuity, Public Anxiety, Education Environment, Property Protection and lastly the Economy.

This order seems to be appropriate because :-

i/ The life safety of the occupants particularly in these case the students and staff must be a first priority and the risks must be reduced to a minimum.

ii/ Then, the continuity of education will have to be reassessed in terms of the possibilities such as the occupants capability to continue, the educational environment, the facilities that continue to be available for use and of course the money to recover fully.
The public will have a lot to ask particularly about the safety of their children who are studying in the school: how safe are the school buildings?, how the administrators are going to manage the accident? Normally, once the public are convinced by the administrator, or the authority, that the school is safe to use only then will the public will be satisfied. Yet the school administration must be able to prove that similar, or any other, accidents are well taken care of and would not happen again.

The educational environment should be re-stabilised and adequate to enable the task of educating the children after such a horrific incident. The police and any outside influence should be away before the schooling system can continue as usual. If not then, there will be a lot of interruption and the main purpose of going to school will not achieved.

The property should be checked against any structural failure and the facilities or buildings must be approved safe before the continuation of education can be achieved. Normally, the building will be used immediately if it is not involved in the fire accident completely and protection measures will be followed as the operation of the schooling system proceeds.

Of course the cost of recovery and maintenance work will be a major topic but then responsible people will consider the means to secure funding for repair and replacement at a later time. This is because the first target will be to see the school performing as usual or better in the shortest time possible. This could require some borrowing or a loan arrangement from a bank or organisation. So long as the children are being educated again without any distraction in their education process, the cost is secondary.
The priority or loss impact issues, if there is a fire accident in the school that will involved everyone's interest:-

<table>
<thead>
<tr>
<th>Fire Safety Objectives to Concern</th>
<th>Average</th>
<th>Overall</th>
<th>Priority Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td>5.90</td>
<td>6</td>
<td>1 Top</td>
</tr>
<tr>
<td>Property Protection</td>
<td>4.67</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Educational Mission Continuity</td>
<td>4.56</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Educational Environment</td>
<td>3.89</td>
<td>4</td>
<td>6 Lowest</td>
</tr>
<tr>
<td>Public Anxiety</td>
<td>4.10</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Economy</td>
<td>4.11</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

where: 0 = not applicable 1 = less priority/less concern/less loss impact, 2, 3, 4, 5 and 6 = highly priority/highly concern/highly loss impact

<table>
<thead>
<tr>
<th>Fire Safety Objectives to Priority</th>
<th>Average</th>
<th>Overall</th>
<th>Priority Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td>5.75</td>
<td>6</td>
<td>1 Top</td>
</tr>
<tr>
<td>Property Protection</td>
<td>4.50</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Educational Mission Continuity</td>
<td>4.30</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Educational Environment</td>
<td>4.00</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Public Anxiety</td>
<td>3.88</td>
<td>4</td>
<td>6 Lowest</td>
</tr>
<tr>
<td>Economy</td>
<td>4.00</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fire Safety Objectives to Loss Impact</th>
<th>Average</th>
<th>Overall</th>
<th>Priority Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td>5.78</td>
<td>6</td>
<td>1 Top</td>
</tr>
<tr>
<td>Property Protection</td>
<td>4.50</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>Educational Mission Continuity</td>
<td>3.88</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Educational Environment</td>
<td>3.75</td>
<td>4</td>
<td>5 Lowest</td>
</tr>
<tr>
<td>Public Anxiety</td>
<td>4.00</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Economy</td>
<td>3.89</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

The points scores in the tables above also show that people are concerned about economy. However, priority should be given to educational mission and environment but the high loss impact would come from life safety and property.
5.8.6.2 Rank The Priority of The Fire Safety Objectives to be Achieved Within Each of The Building Areas in the School Boundary.

where: 0 = not applicable 1 = less priority/less concern/less loss impact, 2, 3, 4, 5 and 6 = highly priority/highly concern/highly loss impact

<table>
<thead>
<tr>
<th>Building Areas To Life Safety</th>
<th>Average</th>
<th>Overall</th>
<th>Priority Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Education Area</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classroom</td>
<td>6.00</td>
<td>6</td>
<td>1 Top</td>
</tr>
<tr>
<td>Library</td>
<td>6.00</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Computer Room</td>
<td>5.90</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Technology Media</td>
<td>5.50</td>
<td>6</td>
<td>3 Lowest</td>
</tr>
<tr>
<td>Laboratory</td>
<td>5.80</td>
<td>6</td>
<td>1 Top</td>
</tr>
<tr>
<td>Workshop</td>
<td>5.60</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Home Science</td>
<td>5.60</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Agricultural Science</td>
<td>5.50</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Co-operative Shop</td>
<td>5.30</td>
<td>5</td>
<td>4 Lowest</td>
</tr>
<tr>
<td><strong>Administration</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Offices</td>
<td>5.80</td>
<td>6</td>
<td>1 Top</td>
</tr>
<tr>
<td>Staff room</td>
<td>5.80</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td><strong>Hostel/Private</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dormitory</td>
<td>5.80</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Warden Flat</td>
<td>5.80</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Dining hall</td>
<td>5.60</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Single Room</td>
<td>5.70</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Canteen</td>
<td>5.40</td>
<td>5</td>
<td>5 Lowest</td>
</tr>
<tr>
<td><strong>Public</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mosque/Prayer hall</td>
<td>5.80</td>
<td>6</td>
<td>1 Top</td>
</tr>
<tr>
<td>Gymnasium</td>
<td>5.60</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Assembly hall</td>
<td>5.50</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Courts Games</td>
<td>5.40</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Stadium/Field</td>
<td>4.89</td>
<td>5</td>
<td>5 Lowest</td>
</tr>
</tbody>
</table>

The overall score for each of the areas show the high impact areas that need to be given priority concern where the quality of the fire safety objectives is defined. In this case the life safety of the occupants within those areas is most important. Rank orders for a response to the problems are given in the rank column above. For example the public area, the mosque or prayer hall should be looked into before any other building areas categorised under the same headings can be proceed. It works only as a reference for steps to handle the fire safety objectives in terms of life safety at school. It would probably be the same for the other fire safety objectives which
need to be improved in those areas of the building categories. Similar references has also been produced for other related fire safety objectives for the building areas at school and can be obtained in the Appendix 5.6(b).

5.8.6.3 Overall Fire Safety Objectives To Be Achieved within A school Can Be Ranked According To The Following:-

<table>
<thead>
<tr>
<th>Fire Safety Objectives</th>
<th>Average</th>
<th>Overall</th>
<th>Priority Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td>6.00</td>
<td>6</td>
<td>1 Top</td>
</tr>
<tr>
<td>Economic</td>
<td>2.70</td>
<td>3</td>
<td>5 Lowest</td>
</tr>
<tr>
<td>Educational Environment</td>
<td>3.80</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Property Protection</td>
<td>3.80</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Public Anxiety</td>
<td>3.30</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Educational Continuity</td>
<td>4.40</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Therefore the new arrangement of the Fire Safety Objectives of a school and it's priority concern should be:- (Refer to Appendix 5.0 : Part E)

<table>
<thead>
<tr>
<th>Fire Safety Objectives</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td>1</td>
</tr>
<tr>
<td>Educational Continuity</td>
<td>2</td>
</tr>
<tr>
<td>Property Protection</td>
<td>3</td>
</tr>
<tr>
<td>Educational Environment</td>
<td>3</td>
</tr>
<tr>
<td>Public Anxiety</td>
<td>4</td>
</tr>
<tr>
<td>Economic</td>
<td>5</td>
</tr>
</tbody>
</table>

5.9 Conclusion

The study using Delphi method has been very useful in achieving a firm consensus from all the members of the group regarding fire safety in educational establishment. The questionnaire has covered the human aspects and now, the Delphi Group has covered the aspects of building within the premises. The fire safety areas dealt by the Delphi members include the types of buildings, building performances, loss impact, types of premises, the prioritisation and importance of the building areas, types of risk and also the priority of the objectives, tactics and components in achieving the fire safety policy for educational buildings. The summary of the findings is as follows:-
a. School buildings are the most important buildings to be given attention in any community development particularly in view of their contribution towards the development of the nation. However, the authority should always give priority consideration for the educational buildings in term of their maintenance and renovation work, safety provision and any future development as the loss from any disaster particularly fire, may cause a very high impact not only to an individual but also to the nation and the international community.

b. In the second part of the Delphi discussion on the Building Performances and Fire Safety, most of the building performances are related to or contributing towards fire safety at some degree. Fire safety is ranked third of all the 14 building performance characteristics. It is actually very useful as a guideline in dealing with fire safety as part of the building services and performances requirement.

c. The Delphi group agreed that the residential school is the first priority in the study of fire safety for educational buildings because of the confinement of the area and also time spent by the school children within the establishment. Besides, the school's areas also has been divided into several building functions. This enabled to focus the study at later stage when the evaluation and assessment taken place. Priority of areas within buildings also helps to make use of the evaluation checklist more efficient especially dealing with bigger school buildings where priority is the main concern and to allocate budgets. The loss impact of each area that has been discussed can ease the administrator in making decision particularly to find solution for relocation of students during emergency and recovery period.

e. The next part which is also very important and has been considered by the Delphi group discussion was the identification of types of fire threats, occupancy vulnerability (physical, mental and physiological) aspects in escape capability and also common source(s) of fire accidents. Once these factors had been established, it can easily be used by the fire safety evaluator of a building with confidence and knowledge to be able to give better judgement and perception on the safety or risk factors within the survey volume in the process of doing evaluation using the available checklist.
f. The fire safety policy, objectives, tactics and components also have been considered in the Delphi group discussion. These are only the perceptions given by members who are not fire safety professionals in terms of qualifications. However, the discussion is to be able to have both the professional and non-professional perceptions on the same topic of fire safety for the educational establishment. Yet, the outcome was really impressive in terms of the agreement towards achieving the fire safety policy for the educational establishment. It was agreed that life safety as the main priority objectives in achieving the policy and followed by educational continuity, property protection, educational environment, public anxiety and economy in sequence.
References


2. Marchant E.W. et al., Fire Safety Evaluation (Points) Scheme for Patient Areas within Hospital. A report on its origins and development sponsored by the DHSS, Department of Fire Safety Engineering, University of Edinburgh, 1982.


6.0 Fire Risk Assessment: An Introduction

Fire has been recognised for a long time as a major part of the threat within the building design and construction processes as it affects the whole of the community and their activities within buildings. Fire impact could be in the form of direct or indirect losses, fire fatalities or fire injuries of human lives, properties, and may have major impact on the social, environment and economic development. It has been accepted that fire disasters do have a huge impact on the whole society. A serious study on how to reduce the losses from fire will continue to be carried out by researchers, insurance companies, Buildings Standards organisations and other parties with an interest in the impact of fire.

Danger from fire can be defined as the combination of risk and hazard. \( D = H \times R \). Hazard is defined as a set of circumstances that could cause injury or death if a fire occurs. Risk is the probability of occurrence of a hazardous event.

There are three important aspects of fire that needs to be assessed in any fire studies. They are the aspects of Fire Hazard, Fire Risk and Fire Safety. In order to make decisions on fire safety easier and more promising based on the engineering design point of view, predictive tools need to be introduced. These tools will probably involve expert opinions and fire models which can be used to assess the fire hazard associated with the level of severity expected to be within an area with a specified scenario. The fire risk assessment results will assist in the implementation of the fire safety system in those particular areas based upon the similar scenario. This is why the risk assessment must be fully understood and need to be given the appropriate approach for the assessment of fire safety in order to achieve the appropriate results. An example of this is the study of the level of occupants awareness in education buildings which is reported in chapter 4 and also the perceptions of the professionals regarding fire safety requirements at school which is described in Chapter 5.
Basically, the process of decision making for a fire safety system to be installed for a particular area may be considered in the following steps:-

Step 1: Choose the Area
Step 2: Define the Type of Occupancy and Activity(s)
Step 3: Assess The Fire Hazard
Step 4: Assess The Fire Risk
Step 5: The Availability of the Fire Safety System(s)
Step 6: The System Cost and Economics (Value for money)
Step 7: Performance and Maintainability

Most of the above steps have already been examined in the design for the questionnaires for the survey and in the Delphi group discussions. The same steps were used to assist in producing the fire safety evaluation checklist.

Thus, ASTM has defined(1):-

a) Fire Hazard as "the potential for harm to people, property, or operations" (ASTM Terminology Relating to Fire Standard, E 176-91d).

And it presupposes that a fire will take place. Measures the potential for harm with respect to one single scenario.

b) Fire Risk as "Is a measure of fire loss (life, health, animals or property)" that combines(1):

i/ the potential for harm in the various fire scenarios that can occur and

ii/ the probabilities of occurrence of those scenarios, within a specified period, in a defined occupancy or situation.

It does not assume that a fire will take place but it measures the potential for harm in the full range of all possible scenarios, using the probabilities of each one of those scenarios to measure the relative importance of each of them. However, a policy on fire standards has been adopted by the ASTM board. The policy acknowledges the existence of three kinds of fire standard(1):

1/ Fire Test Response Standard
2/ Fire Hazard Assessment Standard
3/ Fire Risk Assessment Standard
Therefore, the main concern of the studies that will be discussed in the following pages topics are mainly regard the understanding of the Fire Risk Assessment. Even though, Chapter 3, Chapter 4 and Chapter 5 did cover areas which included risk and safety assessment, in this chapter it is not only explained in more detail about fire risk assessment but also how the risk assessment has assisted in producing the checklist for the evaluation task.

6.1 Definitions

Definition of risk:

a. A type and degree of danger or peril or loss

b. The relative likelihood of danger or probability that the type and degree of danger or peril or loss will occur. This taking into consideration the severity and frequency aspects of the potential loss.

This underlines all varieties of risk analysis, risk is a characteristic or set of characteristics of a person, a building, a product, a city or any other well defined object.

"Risk analysis" can refer to any systematic approach to characterize the probability and severity of losses associated with any suitable object of analysis. The analysis should be as follows:

i. Able to distinguish significant changes in probability or severity that would be associated with managed changes in the object. Example:

a) If modification is done on the product or building, how does its’ risk change?

b) If a person is being trained, how does his or her risk change?

c) If the location of the fire station could be at these positions, how will the city's risk change?

This can be the risk analysis subject no matter how small or big the item in question as long as it (he or she) can be changed in a managed way where the risk analysis can provide useful information to design the programs that results the change.
Definition of hazard:-

a. The object that is the source of danger

b. Or the measure of the degree of danger. (vague if associated with risk in the practice) (Terminology Relating to Fire Standards ASTM E 176-91d)

c. *Fire Hazard:* is potential for harm associated with fire and "hazard" refers to the severity of loss under specified condition.

*Fire Hazard Analysis* would then be: "Analysis of perils without reference to probabilities".

*Fire Risk Analysis:* always need one or more measures of severity and a probability distribution for each.

Measures of severity could be (3):

i/ Deaths

ii/ Injuries

iii/ Monetary damages. If focus on major events:-

(in a quantitative measures based on a basic fire loss measures)

iv/ Whether or not 10 people died

v/ Whether or not damages exceeded US $50 million.

vi/ Or damages on certain equipment that could affect the ability of the company to continue its operation.

vii/ Severity might be spatial( measure of sq. feet/floors/rooms/etc.)

viii/ Severity could be temporal, e.g.: (time required to reach flash over or the time from ignition to extinguishment).

ix/ Severity also could be in term of points score with no simple physical interpretation.

Diversity of possible measures of severity should dispel----> one common myth about fire risk analysis is that; it is all about average. Any analysis which does not incorporate probabilities is not a fire risk analysis. So, most of the questions proposed to the occupants and Delphi members have only been analysed using the percentages of the average outcome. More details on analysing the questionnaires or Delphi group responses can be undertaken with the help of the statisticians for further studies.
6.2 Fire Risk Assessment Models (FRA)

There have been quite a number of previous studies carried out by other researchers on this topic. Several approaches to the fire problems from the Fire Risk Assessment point of view were introduced. The following are the Fire Risk Assessment Models developed in the past years by some researchers who did the fire studies. The studies have given the ideas and information on how to approach the fire problems in a building or organisation with a risk assessment model using a checklist to evaluate the fire safety performance of the buildings with a proposed procedure.

1/ John M. Watts, Jr. (2)

It is shown that heuristic models of fire safety, which he calls fire risk rating schedules, can be used as indicators of fire safety. It is divided into three level of sophistication:-

a) First, the prediction of heat release rates of upholstered furniture by using a model that combines laboratory scale heat release measurements with various empirical parameters.

b) Second, the basis for ASTM Practice for Assessment of Fire Risk by Occupancy Classification (Commentary), E 931, which developed an occupancy classification based on a Delphi approach and assigned various weighting values to a number of elements. (No longer accepted as a form of FRA but as a simple means to give numerical results to common sense).

c) Third, A trade-off model, again derived from a Delphi approach, to trade-off various fire safety alternatives such as active (smoke detectors, sprinklers) and passive (products with better fire performance) fire protection measures.

2/ Hall (3)

An attempt to clarify what a comprehensive fire risk assessment is and is not. It was described as follows:-

i. Most misconceptions about fire risk analysis. There are three misconceptions about fire risk analysis:-
The failure to realize the enormous diversity of possible measures of severity.

The failure to be explicit and thorough in handling probabilities.

The failure to match the scenarios, the measure of severity, and probability distribution to the needs of the problem.

Key concepts in fire risk analysis show how fire risk is simply one facet of overall risk. Particularly, it contains and explains the types of fires and types of human behaviour that may occur.

It poses question to readers whether to decide if it is a fire risk assessment model or not.

Hall (3) also wrote that in fire risk analysis, disagreements often involve the basic objectives of modelling which is:-

a) what problem are we trying to solve
b) what decision are we trying to make
c) what information is most appropriate and relevant to those questions?

An example of the above approach has been undertaken in Chapter 9 for the deterministic study on the requirement for the use of smoke detector systems in the school buildings such as classroom or laboratory areas of the Malaysian schools.

Hall (3) explained that the aspects of severity and frequency are both part of risk and it underlies all varieties of risk analysis, risk is a characteristic, or set of characteristics, of a person, a building, a product, a city, or any other well defined object. Risk may be a proper description of an object that has a specific hazard potential.

The concept has been discussed by the National Fire Protection Research Foundation (NFPRF) to develop a comprehensive fire risk assessment methodology that could be applied to a large number of fire scenarios and a large number of products.
Risk has been based on the use of the fire hazard model HAZARD 1, followed by an 8-step procedure. These steps are:

i. Select the product/occupancy set. After that,

ii. Choose the representative characteristics which then can be

iii. Incorporated into the fire model.

iv. Then, run model for a base case product of specific interest, for whatever reason.

v. A fire risk assessment is then carried out for the base case.

vi. Change the product characteristics with a new product.

vii. Again the fire risk assessment is being carried out.

viii. The process ends with the two results being compared (v) and (vii).

Four case studies are described (22) as:

(1) Upholstered furniture in residences (the single fire scenario associated with the largest number of fire deaths).

(2) Carpets in offices (a very low fire risk scenario)

(3) Concealed combustible (electrical cables) in hotels (a very low fire risk scenario but one which has been associated with public controversy)

(4) Interior finish in restaurants (a case which would address heavily regulated products and would introduce vertical flame spread into the model).

The results are compared with the fire experience and it suggests that a methodology has been developed that can be applied satisfactorily to a variety of scenarios.

A fire risk assessment methodology applied to the uses of gaseous (Halon 1301) extinguishing systems in computer rooms. The methodology uses occurrence probability data applied to the different failure scenarios for its qualitative procedures. The effects of various measures were analyzed:-

i. Human intervention

ii. Inspection intervals and
iii. System tests.

The scenarios investigated were:
i. An electrical fire inside a computer cabinet
ii. A paper trash fire in the room and
iii. A fire outside the room causing smoke to enter the room.

The result of the extinguishing system used was found to be most effective against the electrical fire but least effective against paper trash fire which can easily reignite once the gas has been diluted.

5/

Barry (4)

A storage facility was examined for a plant with four very large Liquified Petroleum Gas tanks by using a combination of fire risk assessment techniques and engineering judgement. A combination of probabilistic and deterministic modeling techniques were applied to assess the risk of off-site human fatality. The potential events being investigated include:

i. BLEVE (Boiling liquid expanding vapor explosion)
ii. Unconfined vapour cloud explosions
iii. Flash fires

Ignition potential is assessed by taking into consideration:

i. Statistical Data
ii. Fuel Properties.

All the information is condensed into an event tree used to develop the potential fire and explosion scenarios. The resulting risk profiles depict the probability of fatalities occurring based on distance from the facility.

6/

John E. Gillett,: Safety and Loss Prevention Adviser Zeneca Pharmaceuticals (21)

A Rapid Fire Risk Assessment Method was developed to be used internationally in the pharmaceutical industry by John E. Gillet for Zeneca Pharmaceuticals.
In a defined area, the consequences of fire and the likelihood of its occurrence are assessed against the statutory and business safety health and environmental standards using simple check lists. The final assessment is either "acceptable", "unacceptable" or "unknown and needs follow-up".

i. The consequences of a fire in the defined area is assessed on the basis of:-
   a) The expected harm to people
   b) The harm to environment
   c) Harm to fixed and variables assets (i.e. buildings and equipment)
   d) Harm to the business.

ii. The likelihood of a fire in the area is assessed from:
   a) The area fire load (A source of combustible materials must be present)
   b) The likelihood of ignition (An effective source of ignition must be present)
   c) The likelihood of escalation/spread (The fire must escalate)

A simple tables are provided to enable consistent and reliable assessment to be made by assessors with a minimum of fire prevention training. The inspection will be done by individual(s) and marked. The marks will be combined to give an overall assessment.

7/ The University of Sydney (Australia), The Warren Center.(12)

The group developed a fire risk model that could be incorporated into the Australian Building Regulations. Beck et al.(12) has found that fire safety and protection facilities constructed in accordance with current Australian regulatory requirements area significant component of the cost of many buildings in this country. The major objective of design for the effects of fire in buildings is to achieve satisfactory levels of life safety for; a) occupants of the building of fire origin, b) occupants of adjoining buildings and, c) fire brigade personnel. The risk assessment model used is a combination of deterministic models and risk assessment models particularly to identify the cost-effective designs for building fire safety and protection systems. In order to make up a quick or rapid decision on what system is likely to be installed
for a particular area at risk, it is necessary to estimate the likelihood of harmful consequences to people and property, by taking a global, or system view, of fire safety and protection. There are several consideration that Beck et al (12) regarded to be essential for the development of a systematic approach to building fire safety and protection, the subsystems are:-

a) nature of occupancy
b) fire growth and development
c) active subsystems
d) passive subsystems
e) occupant avoidance and
f) fire fighting.

They (12) also stated that the level of fire safety in buildings is a reflection of the complexity interaction between fire growth and spread and human behaviour.

So, the overall study shows that the risk analysis or risk assessment is a vital thing to do in most evaluation work. This purpose is to get as much information as possible on problems, methods or approaches that are available, the level of severity, the technical support, the existence of the technologies, the human behaviour, creating the fire scenarios and the impact of loss. All that has eased and given enough support to the decision makers in making the decisions for the expected fire safety at schools or the educational establishment as a whole. This has made the process of producing the checklist easier that is to be used in the fire safety evaluation procedure. The checklist will be explained in the following Chapters 7 and 8.

6.3 Principle: Risk and Safety

The basic assessment principles that an evaluator needs to know is that he/she needs to understand the nature of fire risk and fire safety. The fire risk has two equally valid descriptions:-
a. the probability of ignition and the seriousness of the consequences of such ignition. This involves the ignition risk and fuel risk which represents smoke and heat load.
b. the number of people and the nature of the property. This covers the life risk and property risk.

However for the fire safety of the existing buildings, where the protection and management are provided, 5 headings have been determined:

a. Prevention - involving the control of the ignition risks and fuels risks.
b. Communication - if ignition occurs, occupants are informed and active system(s) are triggered.
c. Means of escape - able to move to places of safety before the occupants are threatened by the products of combustion.
d. Containment - contain the fire and its products to the smallest possible area by limiting the amount of property likely to be damaged.
e. Extinguishment - is to put the fire out and discontinue the ignition and combustion processes of the fuels available by removing one or more of the fire chain reaction such as oxygen, fuel or heat.

6.3.1 Principal Datums

Here, two principal datums are set. They are as follows:

1. The relative assessment is between one fire safety component performance against another or against an establishment safety standard for building areas. e.g.: Is it better or more valuable to install automatic fire detection or to upgrade the fire resistance doors? or is it more dangerous not to replace old and damaged furniture or not to train staff adequately in fire procedures?

Therefore, guidance should be provided to the owner before any improvement programme should begin or the assessment could be undertaken for the particular evaluation work. A proper reference basis needs to be used throughout the evaluation in order to produce consistent results and a reliable outcome.
2. Bring all the buildings up to a recognised standard. This will still require assessment to determine if the safety factors provided are adequate to the risks which are identified. Most of the risk, hazard and fire safety features have been identified in the previous Chapters 4 and 5 of this study.

6.3.2 Acceptability Principle

The fire safety acceptability principle should constitute the standard or acceptable level of risk and safety. Also, its purpose is to reduce the risks to life and property or other related objectives to the level which the society regards as acceptable.

6.3.2.1 Acceptable Risk

There are three principal causes of fire or explosion emphasized by Rasbash(8):

I/. Human failure

ii/. Failure of mechanical and electrical forces (under human control)

iii/. Natural forces.

So, the risk is actually the measure of danger and severity faced by the human life's and the protected properties or even the activities where a malfunction would cause an unacceptable loss to the individuals, organisations, community or nation.

Starr (9) considered that the problems of acceptable risk with regards to a voluntary activities, the risk is balanced by the individual in terms of reward or convenience. For example, an acceptable level of risk is measured in terms of deaths per person per year, is thought to be between $10^{-2}$ and $10^{-3}$ for the level of risk of death from disease. The risk of death from fire appears to be acceptable at $10^{-5}$ times per person per year by Martin(10). Acceptable depends also on the number of people likely to die in one fire, that is, multiple fatalities fires. Multiple fatality fires quickly arouse public anxiety, especially if the fires occur in public authority controlled buildings such as schools or hospitals. Such fires are rare but can still precipitate hasty legislation because the concepts of public safety carried by people can be distorted easily, where a single fire causing eleven deaths can result in legislation
affecting the school buildings compared to eleven deaths caused separately makes little impact on the population. This is among the reasons why this study has been carried out referring to the accidents mentioned in Chapter 1.

6.3.2.2 Acceptable Safety

The protection of people, their property, environment, activities or missions and buildings from the effects of fire is a continuous activity as long as the building concerned is occupied. Most of the techniques used to achieve the required standards of protection are defined by the authorities and perhaps the insurance companies. These definitions may be in the form of Technical Guidance such as the Approve Document B (37), Fire Precaution Acts (36), and also handbooks (39). However, for the school buildings, the Building Bulletin 7 (38) and the Building By-laws 1984 of Malaysia(16) are among the few other documents related to school premises which are being used as the acceptable safety requirements or standards. This part has been tackled in Chapter 3. However, the initial general list of acceptable fire safety requirements for any building which can be applied to the residential secondary schools in Malaysia has been identified into 25 divisions. (This division process may not be completed):

1. Occupancy
2. Visitor
3. High Risk Area
4. Construction Materials
5. Corridors
6. Staircases
7. Travel Distance
8. Lifts
9. Direct External Access & Exits
10. Communication systems
11. Signs and Fire Notices
12. Interior Finishes
13. Furnishings
14. Electrical Earthing
15. Manual Fire Fighting
16. Training
17. Automatic Suppression
18. Fire Brigade
19. Access To Protected Area
20. Structural Protection
21. Rules and Discipline
22. External Suppression
23. Education
24. Building Services
25. Building layout

(refer to Appendix 6.0 for complete list of divisions and related components)
6.3.3 Equivalency Principle

Two different fire safety strategies mean that they achieve the same level of safety by different methods. It can also be described as "Trade Off". Malhotra (26) also wrote that it has been suggested and it seems to be the practice in certain countries that where approved active fire protection measures are provided it should be possible to allow some relaxation on one or more of the passive measures. Similarly, if a building lacks some of the passive measures, then active systems may be used to improve (reduce) the loss potential.

Among the components of passive protection that have been considered for some relaxation when appropriate active protection measures are present, would be (26):-

1. Fire resistance of elements
2. Size of compartments
3. Minimum escape times or travel distances, and
4. Flame spread requirements.

An example given in the Approved Document at B2-4 is where the maximum size of a compartment in a shop may be doubled when a sprinkler installation is provided. With an automatic fire detection system where it provides an early warning or awareness of fire will give more time to occupants to reach a protected zone and consequently a longer travel distance to reach safety may be allowed. However, if the system provided is not "near perfect", trade-off should not be allowed as it is known that failures occur in practice because of interference with passive measures reported from several fire studies. For example, the penetration of fire barriers by services and the inadequate sealing of openings, shortcomings in workmanship, wear and tear suffered by materials in use will lead to less than 100% reliability even from passive measures. An estimate of the probability of failure of passive measures are not available generally.

However, in the whole process of evaluation there must be some parts or components of the buildings, services and other technology provisions that will be identified as having a positive (+) or negative (-) value towards fire safety. Marchant (28) said that those parts with the same value are candidates for equivalence. With careful judgement, it would be the definition of the purpose of
the parts or components and if the purpose and value is the same then it may be interchangeable. For example; a water sprinkler system will control the growth of a fire. This reduces the severity of the fire. The fire resistance requirement of structural components enable structures to remain stable in fire conditions. Therefore, the operation of a sprinkler system is equivalent to fire resistance.

There has been quite a lot of theoretical information given about the fire risk assessment in this chapter because the process of getting the right approach in producing the checklist for the evaluation purpose really needs to cover a broad area of inter-related fields in fire safety. Besides, in making a decision, one should have adequate knowledge in certain areas in order to be confident and responsible for the decision made by them especially when trying to get the most out of the system(s) available. In this case is the acceptable safety and risk standard requirements at the cost they can reasonably afford, regarding fire safety at school.

The objectives to achieve in terms of Fire Safety Policy for the Educational Establishment has been set to the followings:-

i. Life Safety
ii. Property Protection
iii. Educational Continuity
iv. Educational Environment
v. Public Anxiety
vi. Economy

The objectives also has been confirmed in the Chapter 4 and 5 through the used of questionnaire. Further explanation will be given in Chapter 7 where the process of producing the checklist is elaborated. The Diagram 6.0, is representing the whole concept of fire risk assessment process in the making of the checklist to be used for the evaluation of fire safety performances in the educational buildings. A points scheme method has been introduced in this evaluation procedure.
Diagram 6.0: Fire Risk Assessment Approach Taken to Produce the Fire Safety Evaluation Checklist for the Educational Establishment.

6.4 Asking Questions

In making the fire risk assessment, one need to able to look at things, the buildings, environments, services, the occupants, activities and equipment or systems available in a very critical way. There are many questions to ask and responses to
discuss regarding the problems of fire in schools. The what, why, where, how, who and which questions must be used to the fullest possible extent. Of course the questions should consider the following items depending on how deep the assessment should be. In general, the initial categories of the questions can be arranged into 9 parts or components as follows:-

1. Building Occupants       6. External Environment
2. Building Structure       7. Building Layout
3. Building Content         8. Building Services
5. Internal Environment

Some of the areas concerned has been tackled in the chapter 4 and chapter 5 of this study. This involved the occupants awareness, knowledge and training on fire safety, building areas, types of hazards, safety provision and perceptions either from the occupants or professionals (the Delphi Group Members).

The questions to be asked can be referred to the Appendix 6.1. The purpose of producing many questions is to help making the evaluators mind more alert and also assist as a reminder when doing the evaluation procedure.

The risk assessment of part of a building that has been carried out can be described as follows:- (It is more on the performance of fire safety components)

Example : Door - Is the door adequate to cater for the density flow of the occupants from within the enclosed area?
                - Does the door works ? meaning that it is not locked for any security reason.
                - Are there any other exit doors within the same area?
                - What is the contribution of the door as a means of exit, means of escape, compartmentation and smoke control, during any emergency situation?
                - Does the door have the required fire resistance?
The fire problems as stated by most researchers is a complex and dynamic process. If the method is to be a fire risk analysis, then it must deal with measures of severity, scenarios, and probability distributions. And it must be completely comprehensive with solid reasons for all exclusions. In the effort to make the fire safety evaluation procedure to be a reality and applicable, most of the measures do need to be considered based on the issues being addressed. Hall (3) also stated that it is a challenge to recognize the nature of the decision making which is needed to steadily improve the quality, relevance and understandability of the information available. In any community, the fire problems involved in some type of fire hazard or fire risk analysis or management, whether implicit or explicit, qualitative or quantitative, scientific or impressionistic, of broad scope or narrow scope where the issues should be dictated by the nature of the problem, but not only to illuminate choices in the approach to the analysis. In fire risk analysis, everything is relevant and must be included even though the fire may be of low severity and there is a low probability of fire occurrence, unless it can be proven otherwise. Asking more questions does help to improve the making of a decisions and the relevant literature can be used for indications of which methods are sound and which are still experimental include publications of the National Fire Protection Association (NFPA), ASTM, the Society of Fire Protection Engineers (SFPE), the National Research Council of Canada (NRCC) and the International Association of Fire Safety Science (IAFSS). However, Hall (3) stated that there are always multitudes of reasons for wanting to narrow the focus of an analysis to a few fire scenarios:

i. One reason is the high cost of analysis.

ii. Second reason is the desire to stick to the scenarios we understand best, in terms of the state of the art of physics, chemistry, biochemistry, engineering and other relevant sciences.

6.5.1 Fire Risk Assessment & Building Codes Studies (10)

The following examples of fire risk assessment methods which have been developed by researchers, officials or local authorities of various countries which are expected to give a level of fire safety that would comply with the building code.
These approaches have gained some recognition for their applicability in contributing towards the usefulness of fire risk assessment.

i. Beck et al. (10) stated that the fire risk model can be used to identify cost effective combinations of fire safety measures that will ensure the same level of fire safety that is being mandated with prescriptive measures. (Australia)

ii. Hadjisophocleous and Yung (11) investigated 9 combinations of alarm and sprinklers systems which gave a result in terms of expected risk to life and fire cost expectation. It also allows designers to provide a fire performance approach to building design with no greater safety than that prescribed by code requirements. Different approaches was also allow to be chosen which one that has the lowest fire cost expectation. (Canada)

iii. Ministry of Housing, Canada also developed an analytical model to assess the social and economic impact of potential changes to the Building Code. The overall base case fire risk, in terms of property damaged, injury or loss of life is established from fire statistics. A Delphi method was used to prepare the risk event trees that are used to estimate the revised individual probabilities associated with any specific code change proposal and resulting overall risk.

iv. Katzin et al. (12) also using the fire risk assessment aspect to discuss the effects of mandating the use of sprinklers in all new low-rise residential dwellings governed by the Ontario Building Code.

v. Harvey (13) who is a chief officer also using the fire risk assessment method to evaluate fire safety in his community of Boulder, CO. The local planners, building and fire officials, owners, designers and builders worked as a team to use engineering methods for enhancing fire safety in the community while minimizing cost increases. This involves fire protection measure in the buildings and also the number of fire stations and equipment which resulted in an overall cost saving.
6.6 The Approaches Taken in Producing the Checklist

The outcome of the questionnaires and discussions of the Delphi group given in Chapters 4 and 5 are now used to support the ways of selecting the right approach to produce the checklist for the evaluation purpose. In order to understand the ways to evaluate and before that to select the right approach in designing, producing and using the checklist, few other things have to be well understood. These include:-

A. Fire growth phenomena
B. Techniques of fire safety intervention
C. Fire safety technology

6.6.1 Fire Growth Phenomena

Marchant(6) stated that the study of fire phenomena is difficult because of its complexity and a major component of this complexity is the fact that all fires present a dynamic situation for which it is difficult to set appropriate limits to any study. There are many models of various components and divisions of fire safety that have been developed to help in such studies and these include the use of psychological, physical, analogue and mathematical concepts, qualitative and quantitative appraisal, professional judgement and checklists. All attempt to gain some information to improve the understanding and prediction of the complex interaction of fire behaviour and the reaction to fire by people, property and buildings. Similarly, a base for all that must be established in order to ensure that the procedure for the evaluation is consistent throughout the study. The base taken is referred to the nature of fire growth. With these, all the approaches have been standardised using one single reference whenever the evaluation is going to take place. The sequence for the evaluation process and the techniques of intervention are controlled by the fire growth graph (Diagram 6.1).
6.6.1.1 The Nature of Fire (17)

As a fire progresses from ignition to beyond the fully developed stage it is possible to identify four quite distinct parts of its progress. They are the 1) Induction Phase, 2) Rapid Growth, 3) Fully Developed and 4) Decay Phase (refer to Diagram 6.1). The fire probably starts from a very small igniting source (A on the diagram) and as the area affected gradually increases it becomes sizeable (B on the diagram), but still small and will reach a stage (C on the diagram) where the rate of increase of fire size suddenly changes and the phase of rapid growth occurs. Some where in the second stage (C and D on the diagram), the fire will continue to grow until it reaches a maximum intensity (E on the diagram), usually when all the available fuel is completely involved. Then there will be a period of burning in the fully developed state until the fuel starts to become consumed (beginning of (F) stage on the diagram) and the fire enters its decay stage until all the fuel is exhausted and the fire is finished (G on the diagram).

Experience of fire incidents shows that the induction stage (A to C) can be very variable in length of time; it can last for hours or it can be over in minutes, depending on the availability of fuels, oxygen and heat plus the chemical combustion reactions. In the initial stage the fire is small and can probably be dealt with by any available first aid fire fighting equipment but when C on the diagram is passed and rapid growth starts, the fire will certainly be beyond the power of any first aid attack. For analysis purpose the point C represents the time at which the fire is first detected. Thus, point C is taken as zero time and the size of the fire at point C is referred to as "the item first ignited". In the diagram mentioned, there is no sprinkler or fire brigade assumed. For many fire protection design purposes, either for life safety or for the protection of the contents and structures, it is necessary to have some idea of the size of a likely fire so that reasonably correct calculations or estimates can be made.

More detail explanation about the fire growth can be referred to the Fire Engineering, CIBSE Guide E in which is a comparative study by Bukowski (18).
Temperature Celsius/Fahrenheit

<table>
<thead>
<tr>
<th>Induction Stage</th>
<th>Rapid Growth</th>
<th>Fully Developed</th>
<th>Decay Phase</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
</tbody>
</table>

Time (seconds)

Diagram 6.1: Fire Growth Graph and Stages of Fire Development (28).

**Agenda:**

(I)-->(V) Stages of Fire Safety Development in Building Life Cycle (refer Diagram 3.2)

<table>
<thead>
<tr>
<th>Stages:</th>
<th>Intervention Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (A) ---&gt;Pre Fire</td>
<td>- Education / Environmental Monitoring</td>
</tr>
<tr>
<td>(B) ---&gt;Incipient Fire</td>
<td>- Detection System and Alarm System</td>
</tr>
<tr>
<td></td>
<td>- Housekeeping / Discipline / Regulations</td>
</tr>
<tr>
<td>2. (C) ---&gt;Fire Threat</td>
<td>- Detection System and Alarm System</td>
</tr>
<tr>
<td></td>
<td>- Smoke Control / Warning System / First Aid</td>
</tr>
<tr>
<td></td>
<td>- Fire Fighting / Means of Escape / Fire</td>
</tr>
<tr>
<td></td>
<td>- Suppression / Fire Fighting / Smoke Release</td>
</tr>
<tr>
<td></td>
<td>- Passive Fire Control (Structural Resistance)</td>
</tr>
<tr>
<td>(D) ---&gt;Fire Growth</td>
<td>- Means of Escape / Fire Suppression / Fire</td>
</tr>
<tr>
<td></td>
<td>- Fighting / Smoke Release / Passive Fire</td>
</tr>
<tr>
<td></td>
<td>- Control (Structural Resistant) Structural</td>
</tr>
<tr>
<td></td>
<td>- Response / Fire Brigade</td>
</tr>
<tr>
<td>3. (E) ---&gt;Fire Fully Developed</td>
<td>- Hydrant and External Suppression System</td>
</tr>
<tr>
<td></td>
<td>- Structural Response / Fire Brigade</td>
</tr>
<tr>
<td>4. (F) ---&gt;Fire Decay</td>
<td></td>
</tr>
<tr>
<td>(G) ---&gt;Fire Extinguished</td>
<td></td>
</tr>
</tbody>
</table>
6.6.2 Techniques of Fire Intervention

These techniques are very useful as a base reference in doing the evaluation. They are a step to approach the fire problems, designing the checklist, knowing the limit of each intervention technique with the fire safety technology available and to be able to assess the performance of the building against fire as a whole. Marchant(6) did comment that the study of fire safety is complicated further because fire is a phenomenon of rare occurrence for a particular building and even more rare for the individual occupant.

However, with a subject as complex and as imprecise as fire safety, any method which stimulates human or fire behaviour and evaluation decision making about the fire safety systems available for particular buildings with a close estimate to reality will be useful. Therefore, from the study of the Uniform Building by-laws 1984, Law of Malaysia an analysis of Part VII and Part VIII (16), has come out with the list of frequencies for fire safety requirements (general list) based upon the techniques of fire intervention and fire growth graph (refer to Appendix 6.2). The Appendix 6.2 can only be used as a reference on which the priority among the safety components has been considered within the intervention techniques according to categories (A) to (H). The fire problems are being formulated into the following parts:

a) Building Design Requirements
   A - Materials for construction
   B - Decision organisation
   C - Building categories
   D - Building Areas
   E - Building Services
   F - Structural
   G - Environment
   H - Fire safety.

b) Intervention Techniques: There are 10 major fire intervention techniques which have been identified in the life cycle of a fire in a building:-

1. Education and Training
2. Environmental Monitoring
3. Detection System
4. Alarm and Warning System
5. First Aid Fire Fighting
6. Evacuation by means of escape, egress and access.
7. Suppression System
8. Smoke Control System or Containment
9. Passive Fire Control
10. Structural Response

c) Safety components (refer to the Appendix 6.2)

The relevant information is derived from the list of frequency for fire safety requirement set by the Building by-laws (refer to Chapter 3: 3.3.1: Appendix 3.0) can also be arranged into the relevant techniques of fire intervention which are set based on their priority according to the fire growth in a enclosed compartment fire test(18).

Normally the intervention techniques are referred to the severity of fire where one could approach the developing fire and arrest/stop its progress. By referring to the Diagram 6.1, the basic logical steps in fire interventions can be elaborated as follows(20):-

<table>
<thead>
<tr>
<th>Fire Stages</th>
<th>Techniques of Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.6.2.1 Pre Fire (Stage A)</td>
<td>1/ Education:— The education can be in the form of training, attending courses, giving out pamphlets, and demonstrations of fire safety techniques. These involve educating all the levels of personnel starting from school children, staffs, the publics, professionals, managers and also the leaders of any organization. Educational topics may include:-</td>
</tr>
<tr>
<td>a). Design:— i/ Types of buildings.</td>
<td></td>
</tr>
<tr>
<td>ii/ Structural and materials</td>
<td></td>
</tr>
<tr>
<td>iii/ Building regulations</td>
<td></td>
</tr>
<tr>
<td>iv/ etc.</td>
<td></td>
</tr>
<tr>
<td>b). Measurement (size, height, volume, distance)</td>
<td></td>
</tr>
<tr>
<td>c). Management - Emergency Plan</td>
<td></td>
</tr>
<tr>
<td>- Costing and Budgeting</td>
<td></td>
</tr>
<tr>
<td>- System selection.</td>
<td></td>
</tr>
</tbody>
</table>
d). Training (Fire drill, escape and fire fighting operation, first aid)

e). Knowledge on fire, type of fire hazards or risk factors (high, medium, low) and responsibilities.

f). Reminder (posters, assemblies, announcements, pamphlets, etc.)

2/ Environmental Monitoring:- This function should not be limited only to particular areas in the building but include the surroundings of the building. The monitoring steps should cover the following areas:-

a). Boundary (extension, alteration and renovation of any building projection).

b). Access to the site / building for fire brigade and open space areas.

c). Building Services maintenance and building condition. (record, etc.)

d). Risk Assessment - work place, risk and safety factors

e). Checking and monitoring all the means of escape, egress and access, fixed installation and other appliances.

f). Working schedule of the occupancies or the responsible persons such as warden, store keeper, teaching staff, etc.

g). Supervision on the activities and changes in environment.

h). Monitoring the climatic changes in terms of temperature, air flows, natural daylight, mobility within and outside the building.

At these stages, the existence of fire can be extinguished or control at any time with a proper supervision.
6.6.2.2 Incipient Fire (Stage B)

3/ Detection System: This technique will normally integrated with the alarm system. However, the detection system can be categorised into 4 major types:-

i) Heat detector  
ii) Flame detector  
iii) Smoke detector  
iv) Gas detector

All of these detection systems are fixed installations, operating automatically and located according to the types of hazard areas. These detection systems are very important for any active fire protection to be activated and early control of fire can be done such as foam flooding system and/or automatic fire doors for compartmentation.

Alarm systems will then be designed systematically to inform occupants what they need to do, based on where they are and on their ability to respond. Consideration for alarm will based on:-

i) Human - infirm, young, elderly and disabled or incapacitated.  
ii) Manual or automatic.  
iii) Confirmation of alarm and signal given:-
   Visually (Monitor, Emergency lighting)  
   Aurally (P.A system, Bells)  
   Tactile (vibration).  
iv) Response time.

4/ Housekeeping / Discipline / Regulation - The regulation and discipline should be seriously considered by all parties as a user or while being in a particular types of area. (Nature of conduct).
- Habitual (smoking and any other source of ignition should be halted or tightly controlled)  
- Distribution of sources of fuel (including interior decoration, finishes, spacing etc.)

The responsibility of attendants is of high importance, especially if dealing with children, the elderly, infant and disabled people, as soon as fire alarm system is
giving out signals. This stage of fire must be extinguished immediately whenever it is discovered and also if it is out of normal requirements for example the use of flame in laboratory or furnace. Supervision is very important during this fire stage as it could led to fire spread and become dangerous.

6.6.2.3 Fire Threat (Stage C)
5/ Supervision and Alert: This is the starting point where fire can be out of control or the best time to react on total extinguishing of fire. This could be a vital point to be alert about the danger of fire and once the fire becomes well established locally it will continue to grow as long as fuel and oxygen are available. If fire occurs in an unexpected place or very sensitive area then a close supervision is needed in order to avoid any flash over ignition on to the other parts of fuel sources in the same space. Therefore time consumed to undertake any activities within an area must be given serious consideration.

6.6.2.4 Fire Growth (Stage D)
6/ Flame detector: Is the most effective way to detect the existing of fire and almost instantaneous because the light energy travels in a straight line and at the speed of light. It is used generally in high hazard areas with atmospheres in which explosions or rapid fires may occur.

7/ Smoke detector: They are dependable, reliable and require little maintenance. Very often smoke is produced before great heat therefore by using a visual equipment the alarm produced by smoke detector can be convinced from false alarm rate. "Smoke" refers to solid particles or liquid aerosols that are released during combustion and that the particle size in smoke from smouldering fires is larger than in smoke from flaming fires.

8/ Heat detector: They are the simplest, least expensive form of automatic detection, very reliable and have lowest false alarm rate of all detectors. However, they are the slowest to respond.

Most of these detectors are designed to co-operate with the automatic smoke control, alarm system and also flooding extinguishing system. Once the alarm is heard, occupants nearest to the fire should try to extinguish the fire using portable
extinguishers but if dealing with serious fire than any individual involved should call upon help from the emergency services (fire brigade, police, ambulance). The rest of the occupants must be ready for evacuation and having with them the important belongings.

9/ **Active system or by using Warning system:** Normally they are related to the alarm system, emergency lights, and these would include the possible use of central announcement panels and security monitors to inform responsible staff with voice messages to provide instructions for occupant movements and direct remote alarm to supervised stations or fire brigade. Once an alarm is activated or operating, every individual should run to the protected areas. The sequence will probably be from the room to the exit door discharge, and move to protected corridors, down the protected staircases, continue to follow the escape route through the exit doors (egress) into open space and then gather for identification.

10/ **First Aid and Fire Fighting:** During this stage of fire growth, the people who manage to escape out of the building which becomes involved with a serious fire will probably need to be gathered for refuge and given first aid treatment which is important for any emergency victims. Fire is growing rapidly and fire fighting squad should try hard to put the fire under control. They can do this by using some of the fixed installation equipment such as the hose reel, wet and dry riser or even the portable extinguishers (carbon dioxide, foam, water or inert gas). However, the sprinkler system should also being activated but only affecting certain chosen areas to avoid major damage on other properties. Usually, fire fighting is done by trained individuals until they are taken over by the fire brigade people.

11/ **Escape and egress:** In order to make sure that all the possibilities of saving every single life in a burning building, the evacuation period for the occupants to escape is vital and assistance should be given to those who have any disability. This action is to help saving the lives of the occupants and to give more working space fighting against the fire. Escape route should be protected by a flame barrier with fire resistance (according to the standard of 30 minutes). Exit signs, fire doors and smoke doors are useful for compartmentation, having the supply for emergency lighting, no obstructions and lead to outside open space.
By having a escape route plan and training during fire drill, when facing the real emergency situation, the occupants can be safe or escape out of the building safely and systematically (appropriately) without causing any injuries to each other. There are 4 main factors to be born in mind by the occupants and fire brigade during fire emergency:-

a) **Within the fire emergency situation is dark.**

b) Occupants do not have much time.

c) **The heat is killing.**

d) Smoke and gaseous can cause unconsciousness.

### 12/ Fire Suppression:

It is a task where the limiting of fire spread is done by:-

a) Fixed installation such as hose reel which is operated by occupants until the fire brigade arrived especially from the inside of the building. Normally automatic fixed system did not need any people attendance or the hazard is too great to expect people to control the fire.

Types of fixed installation will be:-

i) Automatic sprinklers

ii) Spray localised fire ) Extinguishing systems (these include foam systems, dry chemical systems, inergen and carbon dioxide systems).

iii) Water spray fixed systems (i.e.: water mist system)

b) **Hydrant is being used from outside or the inside of the building.** This will give assistance to the hose reel system available. However, the fire hoses which are connected to the hydrant and the pump on the fire-engine will also be used for external and internal operation to control fire spread.

This task is to make sure that all lives are saved and that the fire brigade will try their best to control or suppress the spread of fire (flash over) and to divert the fire from any other existing fuel in that particular area that would assist the fire growth.
13/ **Smoke Release:** The mechanical smoke extractor is very useful to the fire brigade during the operation. It helps to reduce the level of smoke logging in the building and provides better visual conditions for the escape of occupants and for the fire brigade to fight the fire. It has to be designed carefully so that it will work according to the smoke flows to provide efficient smoke removal. The cost for installation would be expensive if they are not planned from the beginning of the design of the building. This particular area of smoke control has two main functions:

i) To ensure escape path is kept reasonably free from smoke.
ii) To allow the release of heat of the hot smoke and gases from a fire.

14/ **Fire Fighting:** This is the final stage to control the fire and to ensure that all lives are safe including the fire brigade personnel involved. Therefore, the means of access for fire-fighters must be available according to the type of building. These include:

i) Fire fighting access
ii) Smoke doors
iii) Fire lift
iv) Protected shaft

If the fire brigade is not successful to put out the fire then they should also get out of the building as soon as possible. However, during this period the fire brigade officers are controlling the fire growth and some valuable property may be brought out of the building. This task should be done by the professionals and trained individuals because there may be a danger of backdraft. Selected trained personnel will be dealing with life safety and property protection. Normally, the fire brigade only use the hydrant or support systems to control the fire from spreading, except where the fire reaches the stage of being fully developed.

15/ **Passive Fire Control:** The important elements involved are:

i) The structural fire resistance (Integrity, insulation and stability)
ii) Building materials
At this stage, the growth of a fire has become very stable and there are chances for surface spread of flame through heat radiation. Therefore, the needs of vertical and horizontal barrier between an escape route and the rest of the building may be expected to resist fire for a reasonable period which may be as short as 30 minutes. A fire resistance barrier for a period of up to 3 hours would be needed between two parts of a building. The principal conceptual difference between the two types of barrier is that it is assumed that the total human population of a building will be able to evacuate the whole building within 30 minutes. The period of fire resistance (integrity, insulation and stability) assigned to barriers to separate buildings are periods that relate, notionally, to a "complete burnout" of the fuel available on one side of the barrier.

During passive fire control, means of escape and barriers are the main components in building which assist in achieving the objectives of life safety and property protection which also lead towards other related objectives. As the fire growth has already reached the fully developed stage, then the structural stability will be very useful for maintaining the existence of the building and will assist the fire brigade in the life and property saving operations.

6.6.2.5 Fire Fully Developed (Stage E)

16/ Structural Response:- At this particular stage, the duration of the fully developed fire is depending on the fuel availability and chance of ignition. Therefore, building construction and materials used should be of fire resistant and non-combustible materials and this will give the stability, insulation and integrity for the whole building. Normally the important tasks are:-

   i) To stop the fire spread within or nearby the building,

   ii) To keep the structure of the building firm under fire condition and to allow mission continuation after the fire is at a halt.

   iii) To avoid total collapse which could damage everything and increase the total loss.

The fire spread can be reduced by means of compartmentation, fire resistance and structural stability for some period of time until the fully developed fire begins to
decay. However, if the fire can be controlled or contained within the particular area with the help of structural response and water from the fire brigade engine then most probably the fire can be extinguished.

This whole process and period of a fully developed fire is very important for the structure as it may be damaged or may not affected at all. It is important to check the building structure for the continuation of mission which includes recovery and cost effectiveness in the future building valuation on safety and reliability.

6.6.2.6 Fire Decay (Stage F)

First Aid and Fire Fighting: Water, carbon dioxide and foam extinguishers can be used again to finalize the condition of fire to decay and extinguish totally. This will help to extinguish the remnants of smouldering fires, effects of flying brand and irradiated surfaces. It is better to make sure that during this period, no other influence that may cause the fire to develop or grow again, takes place. The steps are:

i) Avoiding the fuel from any combination of combustion process by scattering them away from the source of ignition.

ii) Control the wind by redirect it to a proper direction only. (Building layout or with retaining wall or any erected structure or green belt)

iii) Pressurisation or closed any ventilation supply.

iv) Extinguishing all the smouldering fire and flame that is still available.

Rescue, refuge and safety: This is important to be considered when dealing with a damaged structure or any building structure which are badly affected by the fully developed fire stage. A shield must be built around the contained area and any services from the main supply must be controlled or even cut-off (gas and electricity power supply which probably has been done before the fire gets to the stage C). Any property which is considered to be able to use again shall be rescued for recycling or re-used purposes. Where, 'recycle' suggests disintegration and remoulding into a new product and 're-use' suggests that the building can be reused after repair OR that the components can be reused in other buildings. Such
activities would reduced the level of property loss for better cost effective and mission continuation. During the fully developed and decay fire stages, explosion might occur, so a very careful study of the actual building plan and layout must be given a high priority from the beginning of incident for proper management.

6.6.2.7 Fire Extinguished (Stage G)

19/ Insurance Coverage, Risk Assessment and Investigation: This stage is a serious study which must be done in order to check whether if there is any defect on the structural and services and of course is there any fatalities involved including loss of properties. The investigation is very useful for further decisions about the building progress for the continuation of mission. After all the checking is completed, then the new tender for reconstruction and recovery action will be out to any contractors. The cost of rebuilding will be carried by the insurance companies and by the owner of the building.

20/ Building or Local Authority and Professionals: The architects, engineers, planners, quantity surveyors and environmentalist will decide on the design for the next building design and the fulfillment of the requirements of the building by-laws for all aspects especially involving the fire safety requirements.

Details of the fire intervention techniques are given in the fire technology topic.

6.7 Fire Safety Technology

The third part of the production of the checklist is the fire safety technology available. Fire safety technology is by definition integrative in that a systems approach is required, which includes all of the components e.g.: economics, user requirements and fire dynamics, in order to determine optimum solutions to problems.

There is a lot of technical guidance and product specifications that have been produced by the fire safety engineering manufacturers such as Wormald and Menvier, which provides design handbooks as part of the fire technology marketing
and development strategy. They also help to give information on the up to date technology available in the field of fire safety engineering.

In the following Diagram 6.2, all the three elements of fire growth, intervention techniques and also possible fire safety technology will be combined to explain the inter-connection between fire safety components and level of usage based on the possible fire growth characteristic within a building.

In the fire technology there are two kind of model that are widely used(27):

a). The descriptive fire safety model

b). The derivative fire model.

However, the derivative fire model is likely to be used in the fire safety evaluation process for the schools. This model is in fact an explanation of the integrative nature of fire safety technology and is consequently wider in scope and intellectually more demanding than the descriptive fire safety model. This is because the descriptive model uses current industrial practices and solutions to problems as the basis for future design, for example yesterday's solution is imposed upon tomorrow's problems without a great deal of variation in applications. However, in the derivative fire model, a contextual framework is being used to reinforce all the related current practices which are criticised, analysed and evaluated involving the followings(27):

1. **Functional requirement**: functional efficiency determined via fire safety performance standards.

2. **Aspects of fire safety**: mandatory requirement, moral values, trade-offs, cost-benefit considerations.

3. **Economic and legal considerations**: influence of building legislation and associated costs with alternative design strategies.

4. **Fire safety management**: management of buildings in use, contents and people considered with the client for a particular design strategy.

5. **Project design**: the apportionment of risk between the client and design team with regard to innovative aspects of the design and the establishment of a continuing responsibility for the fire safety performance of the building and its component parts.
6. *Technological change and development*: current research and developments in all aspects of fire safety engineering.

7. *Social consideration*: the interaction between present and future needs of society and the technological means of satisfying them.

8. *User values*: cost-benefit analysis - value for money.

Most of the major input into the system is an explanation of current practice, against the historical backcloths which formulated them together with the development of an attitude of non-dependence towards the status quo. The number of alternative strategies proposed by this derivative model(27), has lead to the use of the points scheme fire safety evaluation approach for application to the residential secondary schools. This are explained in detail in the Chapter 7 where the matrix manipulation of the alternative strategies is developed.
FIRE TECHNOLOGY

Fire Growth Stages

(A)

Education and Training

Monitoring the Environment (e.g.:

Areas/Functions - can use security officers or surveillance camera with computer interaction via monitor.

(B)

Temperature Celsius/°F

(expensive, ionization)

Flame Detection System (have to be in the line of sight)

(appropriate type of detection)

Smoke Detection

(pitched roof, geometry of space)

Heat Detection

(smoke in space)

Smoke Control (preliminary wall, floor)

Purpose:

i) People safety performance

(28000 cu m - 60 minutes)

ii) Fire Brigade movement

(56000 cu m - 90 minutes)

iii) Property safety performance

(No standard to refer)

Warning System

i. Visual warning (deaf people or noisy place)

Acoustic (70dB) at the bed side

attenuation - 120dB temporary deafness

(C)

(Wrist or bed vibrator)

(P.A System with directive message)

ii. Tactile signal (blind people)

iii. Aural Warning (audible)

Fire Fighting and First Aid

Diagram 6.2: Fire Safety Technology Vs Fire Growth

( A complete Fire Technology schedule is given in Appendix 6.3)
In dealing with designing a building against fire, an evaluation scheme should be as comprehensive as possible to be able to give a framework of an equivalent safety system of appraisal. This shows the various choices of fire safety technology to be evaluated against a common standard thereby enabling the most cost-effective measures to be taken.

There is also a need for a social control over fire safety standards especially to avoid a general conflagration which causes the burning of several or many buildings (involving adjacent buildings). The objective of social control is the avoidance of fires that could cause multiple fatalities. Another types of control is the fiscal control (money based). This is usually practiced by insurance companies for the payment of a premium against the cost of loss by fire of the content or fabric of a building.

6.8 Risk Assessment: An Evaluation Process and Consideration

There is a need for a simple evaluation process to give a coarse fire risk classification to the building. Directives of the Council of the European Communities generated two approach(28):

i. A general direction that encourages the overall improvement of the health and safety of the worker at workplace.
ii. Particular areas of health and safety to examine new and existing workplace.

These approaches will categorise the building into high, normal and low risk. So this paper will enable to:

a/ Identify and to evaluate the sufficiency, adequacy or deficiency of each major fire safety component.
b/ To measure the impact of additional or improved specifications for the components of fire safety.

Aspect of building design: interaction between the ordinary performance requirements of a building and their relationships with the changing environment created by an accidental fire. For example, i.e.: energy conservation, thermal insulation, visual and aural environment.
6.8.1 Tools and Considerations:-(for assessments)

Two common approaches can be taken as follows:-

i. Computer aided mathematical model i.e.: Environmental control, thermal properties, reaction of the occupants

ii. Probabilistic input.

Several considerations in doing assessment must be taken in order to achieve the purpose of solving the problems within the limitation :-

a). The targets

b). The specified nature of outcomes (both influences the tools)

c). The amount and quality of the information that is available at the time.

d). The analysis of a problem must be considered in two aspects: it's quality and the level of detail.

e). The assessment should be consistent in terms of standards, systems and costs which can come from different geographical areas.

Example of the empirical engineering mathematical expression is such as design of smoke ventilation and escape routes and sprinkler system. All this gives indirect contributions towards the overall assessment of fire risk for buildings. The Building Industries National Council(BINC)(29) scheme is design to enable the adequacy of an escape route to be assessed. It also gives designers flexibility in the selection of safety components that could be brought together to form an appropriate means of escape. They are also designed to improve local legislation.

The Life Safety Code scheme which is now incorporated within the NFPA codes (30) or code assessing including the patient spaces in hospital, board and care homes and detention centres. It was developed using a Delphi technique. In application a simple level of acceptability can be gained through the assessment of 13 safety components against the risk number, treatment and factors.

Hospital Technical Memorandum (HTM) published in 1987 enabled the appropriate distribution of fire safety budgets between hospital in one group of hospitals and between groups in larger territorial areas.
Houses in Multiple Occupation (HMO) scheme combines the number of people, the height of the building and the geometrical complexity of the building (escape route). All this will give positive selection of the components of fire technology that would be appropriate to secure adequate life safety. However, with the user guide, it would be essential to have the ability to understand simple technical documents, knowledge of buildings and good observational skills.

Fire safety professional should also have useful information on the features of the workplace, knowledge of the capabilities of the workers and the financial burden for the assessment. Any scheme of assessment must show clearly that it is the standard of the fire safety that is being assessed and not the presence or absence of any of the components of fire safety technology.

There are 7 main characteristics of a simple assessment (28):

i. **Objective** - "the standard of fire safety for the worker at the workplace shall be appropriate and sufficient".

ii. **Risk Factors** - the features or characteristics in or around the workplace is a first scenario for assessment. The second scenario is the other workplaces in the same building which fire may occur with respect to the first location.

iii. **Safety factors** - These are features of the building/services that make contribution to the control of the fire threat, the escape of the workers and the stability of the building.

iv. **Balance between risk and safety** - The assessment of the balance between risk and safety is normally done using a prescriptive basis. Risk is not measured but assumed to relate directly with any defined type of building. Risk assessment is to be carried out at the workplace and the specific assessment is likely to define the risk with a greater precision than is practicable using a "code compliant" approach. At least there will be several identified components of risk. Components of fire safety and the standards expected of the components are described and listed in authoritative guide for the type of building. It is then a simple procedure to use the list as a check list where deficiency can then be measured by the absence of a listed component and improvements made by the addition of some or all of the absent components. So, the division of the overall risk will enable a better match between the safety components and the risk components than is
possible with the code complying approach. Therefore, the target balance between risk and safety should be achieved with greater certainty than is practicable with a check list approach alone.

v. **Judgement of acceptability** - The code compliance check list approach to the provision of sufficient safety from fire requires the expert opinion of the assessor to decide whether or not a proposal for risk reduction will result in an acceptable level of fire safety. If sufficient fire data were available and level of probable risk were agreed generally then the probabilistic approach to fire safety assessment would produce outcomes that would specify the level of safety achieved by improvement that were proposed or that were achieved. The probabilistic approach is not simple nor is it sufficiently well developed for application to a broad based fire risk assessment. In the context of the workplace it seems that it would be best if the assessment scheme was self-judging so that the opinion of the individual assessors does not need to be exercised in the production of the final outcome of an assessment. Such a scheme would need to be capable of consistent application and capable of producing consistent results that judge acceptability "automatically". The Building Industries National Council system of evaluation(29) and the scheme for the evaluation of patient spaces in hospitals(34) both contain positive guidance on the acceptability of the standards of fire safety generated by the application of the assessment procedure.

vi. **Simplicity of operation** - Simplicity should be an essential characteristic of an assessment scheme developed for the use of the owner of the building as the scheme will be used by an intelligent person but a person that may have no knowledge of fire safety engineering. The scheme will need to be very clear about the definition of the components to be measured and about the process of measurement and the values to be attributed to each of the assessed components.

vii. **Contribution to cost-effective fire safety.** An emphasis in the directives that the application of the standards implied by the directives and the standards that are implicit in the draft regulations and the draft code of practice should not be a financial burden to medium and small industry.
Progress towards standard definitions will be made based on relevant existing documents which may be analysed in terms of the purpose of the content, the level of the guidance and the contribution that each part of the content would make to the safety of the occupants, workers and any associated persons. The guidance in such publications is targeted at the provision of fire safety for the protection of life.

In order to facilitate the analysis several levels of statement in the documents, they were classified generally as:

i. **Statement of intent**—i.e., "each and every building should be provided with an adequate and appropriate level of safety against the effects of an accidental fire.

ii. **Performance statements**—i.e., a wall may be expected to have a fire resistance performance of 2 hours duration in the standard furnace test for the three measured performance characteristic that are: stability, integrity and insulation. Sometimes, the terminology of performance specification and performance requirements are used alternatively.

iii. **Statements of specification**—define the nature and/or properties of materials, objects or products and are usually specific in terms of quantity. A useful check list could be developed from complete specifications.

### 6.8.2 Carrying Out Assessment

Assessment starts with the minimisation of the chance of ignition. This objective is conditioned strongly by the attitudes of the building occupants. So, if prevention fails and ignition occurs, next the fire safety characteristics of the work station given that ignition has occurred then it will produce smoke and followed by the threat. There could be a need for smoke control system to extend the time available for escape. After the successful completion of escape procedures, if fire continues then usually the area affected will have been attained with fire fighting or fire suppression techniques followed by structural resistance until the fire is under controlled and starts to enter the decay phase and extinguished. Usually it's main
purpose after the completion of escape procedure is just to ensure that the remaining fire safety objectives is achieved.

Fire scenario: It is used to define the framework for the observational assessment where there are 6 scenarios being suggested (31):

- i. smouldering fire with door open
- ii. smouldering fire with door closed
- iii. flaming non-flash over fire with door open
- iv. flaming non-flash over fire with door closed
- v. flash over fire with door open
- vi. flash over fire with door closed

There are also 6 steps in the assessment sequence in the development of a simple approach to evaluation and equivalence that has been generated through several studies (32):

- i. Classify the building and its occupants
- ii. Select and quantify the design fires
- iii. Predict smoke and gas spread
- iv. Predict the response of the occupants
- v. Predict intervention by the fire brigade, and
- vi. Outcome prediction.

The 7 phase fire development sequence are:-

- i. Pre fire (A)
- ii. Fire incident (B)
- iii. Fire Threat (C)
- iv. Fire Growth (D)
- v. Fire Fully Developed (E)
- vi. Fire Decay (F)
- vii. Fire Extinguished (G)

This has been clearly explained in the earlier paragraph 6.6.1 and 6.6.2. Normally in phases A & B there will not be a response to the fire detection system. We call it malfunction. Then the following sequence is that of ignition, flash over and lastly the onset of decay.
Diagram 6.3: Fire Growth and Fire Technology

The safety components could be translated into a simple numerical sequence to give weighting factors. As in phase C and D (Diagram 6.3) there are 11 components:

1. Flame detection  
2. Smoke detection  
3. Heat detection  
4. Warning systems  
5. First aid fire fighting  
6. Escape  
7. Fire suppression  
8. Smoke release  
9. Fire fighting  
10. Passive Fire Control  
11. Structural response
Components of fire safety are divided into two large areas of fire which are represented by (33):-

a. Emergency routes and exits
b. Fire detection and fire fighting
   i. Routes must remain clear and lead directly to open air or a safe place.
   ii. All workstations must be capable of being evacuated quickly and safely.
   iii. The distribution and capacity of the routes and exits must be sufficient for the risk.
   iv. Emergency doors should open easily and not be sliding or evolving doors.
   v. Routes should be indicated with proper signs.
   vi. Emergency doors should be locked and the routes should have no obstructions.
   vii. Emergency lighting should be provided where necessary on escape routes.
   viii. Fire fighting equipment should be provided appropriate to the risk together with necessary fire detection and alarm systems.
   ix. Non-automatic fire fighting equipment must be accessible readily and simple to use, indicated by appropriate signs which are located properly and that are made to last.

6.8.3 List of components

a/ Population - The assessment needs to cover the psychological, physiological and physical characteristics of each person at the workplace and of each visitor to the workplace. (Their ability to respond to an emergency).

b/ Workstation - (-) the assessment of the risk of ignition presented by the task to be carried out,
   (+) the personal protection from an ignition
   (-) the workplace as a collection of fuel
   (+) communication of the fact of a fire threat
   (+) the geometry of the workstation
the location of the workstation in the building space  
the essential mechanical plant association with the task.  
available means for immediate threat control  
the escape route from the workstation

The negative and positive sign given for each statement above is to show the sign of contributing towards safety features(+) or more towards threat features(-).

cl  The building:- Several features of the building are important to the fire safety, includes:-
   i. the number of routes away from the space around the workstation
   ii. the surface finishes of the building space  
   iii. the size of the building space around the workstation especially the volume of the space.  
   iv. height of the floor of the workplace above the ground  
   v. the adequacy of the escape paths around the building space and from the building.

Number(iii) is important for the design and selection of smoke control system. Other factors will include the vulnerability of the contents.

d/  Fire safety technology:
   i. Detection of the products of combustion:- (flame, heat, smoke including surveillance systems)
   ii. The control of the spread of smoke:- (ventilation, volume, extraction, barriers)
   iii. Warning systems:- (natural voice, sound light, recorded voice, directed message)
   iv. First aid fire fighting:- (sand, water bucket, extinguishers, hose reels)
   v. Escape system:- (colour schemes, illumination, obstacles, signage, pathways, floor slipperiness, location and capacity of exits from the space, safe waiting areas, escape lifts, capacity of staircases (total or phased evacuation)
   vi. Fire suppression:- (water sprinklers, partial or total gaseous flooding systems, drencher system, steam systems)
vii. **Smoke release:** (cross ventilation, roof vent, windows, ducts)

viii. **Fire fighting:** (approach to the building and hard standing, hydrants, access for fire fighters, fire fighting shafts, fireman's lifts, rescue facilities, dry risers, wet risers, drainage, pump power)

ix. **Passive fire control:** (Compartmentation, separation, barriers, cavities, ducts, doors, glazed panels, pipes, cables, fire stopping)

x. **Structural response:** (fuel, ignition, ventilation, fire severity, fire control, fire resistance, stability, premature collapse)

All the above mentioned, will need to be brought together so that the overall evaluation of the workplace can be described as "High", "Medium/Normal", or "Low" risk. The next coming chapter is explaining the approaches taken to form the checklist for the evaluation which has been generated through the study of risk assessment and using the help of the expert opinion.

6.9 **Conclusion**

Although the procedure outlined may seem to be complicated, it may be one way to enable an appropriate fire risk assessment system to be developed. The assessment system that is developed will need to be sufficiently robust for minor modifications to be made without any loss of confidence in the validity of the outcomes of the application of the procedure.

Basically the fire risk assessment approach that has been taken throughout the study is more or less similar to the model which Hall (1) has been engaged in his studies. The whole study of the risk assessment is about getting the right answer to all the problems stated below:

a. The problems to solve.

b. The building or organization involved.

c. The areas, occupancy and functions.

d. The Hazard, Risk and Safety Factors.

e. The basic reference for assessment - Fire growth graph as the scenario.

f. The common technology available.

g. The intervention techniques.
g. The information for the formation of evaluation checklist.

Also the evaluation of the patient areas in hospital by Marchant(24) is being referred. There are a lot more references that one can look at in order to do an assessment. Among the guidance fire assessment that can be carried out on a building is the assessment on the places of work. The proposed methodology for fire risk assessment is well defined and explained in the "Guide to the Fire Precautions (Places of Work) Regulations, 1994", a Public Consultation Document of September 1994. Generally the fire risk assessment method can be described in the following diagram 6.4 (35).
There are several problems with the setting of the fire scenario where it is suggested that fire risk should always be defined in terms of the probability of a fire, but one does not have the luxury of choosing the fire that one will have. The problems are (25); First, if enough characteristics are applied to the definition of a fire, its probability may be arbitrarily small and second, it is more likely that a questions or decision will be posed in terms of the effect of a particular object on risk in the full range of fires in which it might be involved. So by referring to the fire growth graph, any fire scenario can be tackled depending on the level of severity and the action that the occupants or manager need to be made can easily be followed or implemented (practiced). Another way of doing an early assessment is by introducing the fire safety audit and doing a regular evaluation. This evaluation is introduced in the following chapters of this study. An example of a systematic approach to practical Fire Risk Assessment is given in the Appendix 6.4 (40).

Generally, the summary of all the fire hazards in Malaysian schools were caused by:-

a) The occupants carelessness when dealing with naked fire sources such as candle light and oil lamp.

b) The wide use of combustible materials for buildings structures and components.

c) Lack of electricity wiring maintenance and also using an unsafe electrical equipments.

d) Most of the fire safety equipment installed was not working or maintained i.e.: alarm bell, fire extinguishers and exit door.

e) Low water pressure for the hydrant.

f) Lack of budget and management in terms of fire safety.

g) Fire safety knowledge and training is inadequate amongst the occupants.

The above fire hazards were obtained from the Chapter 2. In order to overcome the problems, an evaluation on the fire safety requirements for the buildings involved must be undertaken. The process of creating the evaluation procedure requires a very serious decision making steps and vast understanding of the whole related subjects such as the building regulations, occupancy responses and level of awareness and risk analysis, fire growth phenomenon, and the possible approach to carry out the evaluation task to solve the problems. Therefore, a comprehensive
study of all the fire safety subjects above are needed to be able to understand the problems and overcome the fire problems using the proper approaches. The following chapter is concerning on the formation of the checklist resulted from the fire risk assessment analysis which has been done with the information given throughout the previous chapters. The information given through the fire risk assessment on the relevant building, activities and its occupancies are needed to be able to evaluate the performance of fire safety. Even though, most of the feedback are generally giving a quantitative appraisal but with the help of the Delphi Group, checklist and points scheme approach which are introduced in the next chapters are expected to give some qualitative appraisal. It has been tested using photographs taken during several visits to the local residential secondary school in Malaysia based on the evaluation point scheme methodology.

The main target is to achieve the objectives set for the Fire Safety Policy in the Educational Establishment particularly the fully residential secondary schools, where a satisfactory and acceptable level of fire safety within the occupied buildings or areas are obtained based on the regulatory requirements or standard. It also enabled trade-off to be undertaken for more practical solutions and cost-beneficial results.


24. Fire Safety Evaluation (Points) Scheme For Patient Areas within Hospitals, Department of Fire Safety Engineering, University of Edinburgh, 1982.


40. Systematic Approach To Practical Fire Risk Assessment, unknown notes.
CHAPTER 7: FIRE SAFETY COMPONENTS PERFORMANCE APPRAISAL (CHECK LIST 2)

7.0 Introduction

Overall, the evaluation procedure for fire safety introduced for the educational establishment in Malaysia has been formed using fuzzy techniques (1) which involve uncertainties such as human behaviour, performance of the fire safety installation, human and fire responses during an emergency, and particularly smoke and fire spread. However, the evaluation procedure is based on the contribution of each policy, objective, tactic, technique of intervention and component to the principal objectives of adequate and appropriate standards of fire safety. The contribution may be to reduce the vulnerability of the occupants or the environment to fire attack or their contribution to a direct increase in the level of fire safety which are assessed by their contribution of points of vulnerability or safety. The procedure is organised and it has been arranged in terms of intervention techniques which follows the Fire Growth Graph at all levels of the check list (Components, Intervention Techniques and Tactics).

The fire safety evaluation framework for this study is divided into 4 parts:

i. Quantitative appraisal
ii. Qualitative appraisal
iii. Check List
iv. Professional Judgement

The quantitative appraisal has been undertaken using a physical model to investigate the optimal location of the smoke detector location. This is considered in the Chapter 9, and it is also a part of fire safety engineering evaluation techniques to be applied in a building.

The qualitative appraisal was then obtained through the questionnaire described in Chapter 4. It provides the information on the occupancy level of awareness and knowledge about fire safety, the safety and hazard or risk conditions within the workplace (generally in secondary schools), and also some suggestions the future
improvement that they expect or assume to be provided by the school authorities. There were also two other sets of questionnaires which have been designed to obtain information and feed back from the members of the Delphi Groups(1 and 2) especially to design the check list and the evaluation points scheme, regarding fire safety for secondary schools. And these are covered in Chapter 5, 7 and 8 of this study. Besides, the professional judgment also has been considered in this part by looking at the regulations, codes and standards in Chapter 3. The unavailability of statistically derived input data can be overcome, in this context, by the use of expert judgment (3).

After all the information gathering, it is time that the check list to be produced for the evaluation techniques using points scheme similarly done on the Hospital Patient Areas (2) and also Dwellings (3). A set of check lists to be used for the evaluation of the educational establishment has been derived from all the previous work done within Chapter 2 till Chapter 6. However, the process of producing the check list requires several factors and know-how information to enable it to exist and to be practically tested.

7.1 Know-How and Knowledge Acquisition

Schools will always be a priority on the agenda for the government and the public. Eventhough it does not involve normal building regulations and requirements the government always have to ensure that the level of safety against any disasters, particularly the fire, is fulfilled. One way of getting this matter across to all the occupants and related bodies, an evaluation scheme on fire safety of the schools buildings must be available. An enormous amount of information needs to be gathered together to form a check list for the evaluation task and this requires knowledge and also know-how for components to react effectively within the use of the checklist. The know-how and knowledge can be gained through several approaches, such as survey studies, statistical data from any statistics organisations, fire reports, building regulations and legislation, previous studies, experimental work and also using professional judgment as suggested by most studies within Delphi group.
Diagram 7.0 is shows that the process of making decisions either for design of the check list or to evaluate the fire safety systems within a building, requires a lot of data input which are inter-related within the dotted line before one enable to make a decision. The check list and also the evaluation techniques has taken the above approach. The comprehensive study is very good for better understanding of the whole process of the evaluation procedure and to gain adequate information in solving the problems or proposing solutions. However, individuals who were involved with different level of contribution for the studies are only requested to gain certain level of knowledge of the know-how contributory elements.

In this context, a decision process may be characterised by knowledge which defines the nature of the desired outcomes and know-how which determines the course of action which will ensure the achievement of the desired outcomes(3). There is an interdependency between knowledge and know-how, therefore, a training program, or course, may need to be applied or given to the new inexperienced evaluator based on the guidelines proposed by this study. So, the approach taken for the development of the fire safety evaluation procedure is given below:-
1. Questionnaire
2. Delphi Group
3. Professional Judgment (fire group)
4. Experimental Evaluation via Engineering Views
5. Practicality of the Application Evaluation Scheme on Existing School

The whole procedure is explained in Chapter 8 but the application of fire safety engineering is in Chapter 9 of this study.

7.2 Decision Making In Fire Safety

Fire safety is a generic term involving many inter-related concepts such as fire protection and fire prevention, which are sub divided into several more components and sub components and most of them leads to certain tactics of confronting fire problems in order to achieve set objectives of a policy for a particular building. All this need a better understanding of the whole interrelated concept in fire safety which can be arranged in a hierarchical framework or a decision tree. The hierarchical framework is explained in Chapter 8. Most administrators and local authorities are the group of decision makers. It is very useful to understand the powerful of making decision as the consequences of the results could be positive for the solutions of the problems or may be it could also be a negative impact that worsen the existing problems. The fire safety engineers, scientists and managers will always have to be critically aware of the elements in solving problems or in making decisions. Basically, there are 4 major elements:

1/ **Choice of among issues that require attention.**

Example:- Fires in Educational Establishments
The issues could be the Evaluation of Fire Safety Standard for Secondary Boarding School, involving the hostel areas, comfort level, teaching and learning facilities, arson, community centres for natural disasters, local gathering or even national events where the questions are specifically about the safety of the occupants being at school. Are they really safe?
2/ Identify objectives.

Example:-

a) Life Safety ---> School Children/Staff/Local Community

b) Property Protection ---> Hostel/Classroom/Laboratory/Offices/Records etc.

c) Educational Continuity--->Teaching and learning/mental, physical and spiritual development.

d) Environmental --->(Living and studying) Safety / Comfort / Transportation

e) Public Anxiety ---> Government Policy/Political Issues/ Public Interest


The main priority will be the live’s of all of the occupants within the educational establishment and also the one that can be affected outside the school boundary in case of fire disaster.

3/ Find or design suitable courses of action.

Example:-

I. Establishing the level of awareness among the occupants of the educational buildings.

II. Comply with the current situation of fire safety within the school with the requirement of the building regulations or the Uniform Building by-law 1984 (4), Fire Precaution Act 1971 (14) and other building codes.

III. Establishing the “Norm”.

IV. Check List and Fire Technology

V. Fire Safety and Fire Risk Assessment (Safety and Risk factors)

Most of the above mentioned have been undertaken and they are elaborated in the previous chapters except the check list which is incorporated with the Norm of the fire safety components within a building and undertaken assessment task.
4/ Evaluate Alternatives.
Example:-

a) Probabilistic Evaluation --> Questionnaires
b) Deterministic Evaluation --> Experimental work (For example: Smoke Detector Location for Variable Pitch Ceiling or Roof.)
c) Professional Judgement/Opinion Evaluation --> Delphi Group
d) Performance Evaluation --> Fire technology/Fire Brigade mobility/ Hydrant/Occupants

Therefore, the check list should be set as critical as possible to the level of being able to get the information required for the evaluation purposes. This is the reason "why" an evaluator needs to be accommodated with a comprehensive background knowledge of fire safety to be applied to the check list during assessment evaluation. Using the data obtained from the document analysis of the Chapter 3, the check list for the fire safety has been developed initially with the establishment of the fire safety "Norm" components followed by the types of occupancies, types of building categories and areas, types of hazards and risk, before they are being incorporated with the fire safety policy, objectives and also tactics for the educational establishment.

7.3 Establishing The "NORM" of Fire Safety Components Within a Building

The Norm for the Educational Fire Safety Requirement is being selected from the Uniform Building By-laws 1984 the Law of Malaysia (4) which is one of the main references for building construction in Malaysia. There are 7 major divisions that can be used by the researcher with the reference to the Uniform Building by-laws 1984 (4). The list of divisions are as follows:-

1. Materials For Construction
2. Building Categories or Types Decision Bodies and Design Team
3. Building Areas
4. Building Services
Most of the divisions are interconnected to one another. Even some of the divisions can be grouped under a major category where the particular requirement of the division involves the rest of the list. Fire safety requirements as a whole does involve most of the division of the Uniform Building By Laws. However, the authorities, professionals and design team that involve in making decision for the design requirement, construction, installation and expenditure towards safer building can also be obtained from the document.

The materials for construction is a part of the fire safety requirement division as the decision on types of materials will significantly influence the possibility of fire spread or source of fuels. Therefore, the designer needs to decide on either combustible or non combustible materials to be used in the construction of the particular building. Other divisions which are thought to be involved and similar components to be grouped under the fire safety requirement division are the rest of the division list. Building categories or types, the building areas, building services, structural systems and environmental systems will assist in fulfilling the other objectives within the Fire Safety Policy for the particular building for example the structural resistivity, stability and integrity are among the criteria for the fire safety of the building. Normally structure is very important in measuring the strength or the fire resistance against fire as long as it's existence.

7.3.1 Fire Safety Components

The following Norm is seems to be complimented with the Fire Safety Requirement set in the Uniform Building by-law 1984(4). The Norm for Educational Fire Safety Components For Schools In Malaysia is as follows:-

1. Students/ Teachers/Staff

These are the major occupancies within the school boundary. Without one of them, the objectives of education in a school or specifically a Boarding School(Secondary) will not achieved.
2. **Visitors**

This type of occupancy should not be excluded as it is also a part of the system which could be very important to be considered throughout the educational process especially involving the parents of the children staying in the hostel, relatives, surrounding societies and also school events or activities, where these will involve participation of other groups of population within the school boundary. They are probably among those who are not familiar with the school environment and restrictions.

3. **Hazard Protection**

The hazards within the school buildings can be diverse and differences could be according to the usage of the areas and activities within them. In this case, the main reference is the hazard which caused or related to fire. The fire safety protections involved in this category would be the fire alarm, fire detectors and fire extinguishing equipments.

4. **Interior Finish**

This involves the materials used for wall, floor and ceiling finishes. It's contribution to fire safety is that it assist in reducing the spread of fire or the source of fuel in the case of fire emergency if proper materials are being chosen.

5. **Furnishing or Furniture**

The other important factors that really needs a serious consideration is the furniture used within the areas in the school. Furniture can contribute towards the source of fuel if it's materials are wrongly chosen. Besides, the arrangement of the furniture in an area will determine the ease of occupancy mobility and the time to escape during any emergency.

6. **Fire Prevention**

In this category, the preventative steps taken should be more effectively to reduce the incidence of fire accident or limit the severity of the fire. Normally the preventative steps involved are such as the education in fire safety, training and building structures.
7. **Corridors**
A lot of the school buildings in Malaysia having corridors connecting each of the areas or nearby buildings of the same floors. Normally the corridors in tropical country such as Malaysia are non protected types and exposed directly to external environment. It is a means for horizontal air movement within the buildings.

8. **Staircases**
Staircases are also vertical structures that connecting different floors and normally lead to the top floor or the external egress at ground floor. Location, size and steepness of the staircases are among the fire safety requirement factors that need to be considered in designing for safety.

9. **Lift (Sometimes)**
The function of a lift is for vertical transportation within the building. However, the buildings within the school boundary are normally built only up to 4 storey height where the requirement of a lift is not compulsory. But there is another purpose of having the lift as the vertical transportation; it is for the lifting heavy equipment or even in some cases for the disabled use and is more widely found in the higher education system such as the colleges and universities than in a secondary school.

10. **Signs and Fire Notices (including Emergency Lighting)**
The fire safety requirement in a building also includes the signs and fire notices within the buildings. It works as a reminder or point where direction and emergency instructions are given. The notices or signs are usually highlighted with some kind of power supply from different sources besides the main electrical cable.

11. **Communication (Emergency Telephone/BreakableGlass/PA. System)**
Among the normal means of communication within a building will probably be the telephone or inter-comm., an announcement using the public addresses system or signals such as the ringing bell. This factor is very important because it assists in informing other the actions to do or telling others what is going on about the current situation within the school.
12. **Travel Distance**
Consideration should also be given to the travel distance between places or areas within the buildings in order to determine the time taken for every individual or group of people to move from a place to the other or safer place, normally the open space outside the buildings.

13. **Manual Fire Fighting**
Individuals can also react towards reduction of the severity of fire especially in the earlier stage of fire growth. Usually the types of equipment used by individuals to fight fire are the fire extinguishers containing either foam, water, carbon dioxide or even Halon. The location of all these fire extinguishers should be at a place where people can find them easily and must state the right application for the right type of fire. Other kinds of fire fighting would be the hose reel and, may be, the dry or wet riser system.

14. **Automatic Suppression**
This feature involves a bigger tank of extinguishant or suppression agents and a fixed installation piping system. It can be designed as a localised or flooding type of suppression techniques. The agent can be the same as the manual fire fighting extinguishing agent such as the water spray, foam, carbon dioxide and halon. Note that the usage of halon gas is now being replaced with some other ozone friendly types of extinguishing agents such as inert gas.

15. **Fire Brigade**
Besides the occupants of the building or school, the fire brigade officers should also be included as part of the fire safety component of a building, in this case the educational buildings. The fire brigades will react upon receiving the calls from the scene of the fire emergency. They normally make sure that the place is secured from any other intruders and control the fire from outside and towards inside of the buildings. Their important function is to help the occupancy of the building to be safely evacuated and making sure that there is no other person trapped in that building and along with that is to control the fire until the fire is finally extinguished. They will
probably try to save the property or building from any major destruction and stop the spreading of fire to any nearby buildings.

16. **Direct External Egress**
The building design must always have a direct external egress to an open space where it is a place safe from the harm of the fire. Any building areas will have to be connected to an open space and away from the building.

17. **Access To Protected Area (Refuge Area)**
There should be an access to protected areas either protected access or corridors specially built and covered with roof. This will assist the first aid or any emergency rescue work that need to be effectively victorious particularly for Malaysia climatic conditions to avoid heavy rain and direct sunlight.

18. **Ducts/Shafts and Cavities**
In the Malaysian context, the school will normally not have an air conditioning ducting system built into the building in the construction stages. However the systems that will be installed are the window type units where only specific areas are given the opportunity of air conditioning (AC). However, the increasing demand for the air conditioning unit will probably change the future construction of a school building and the AC unit will be installed earlier in order to reduce the damage done to the structure and to consider the aesthetic value of the school building. The roof void is also a very serious structures that normally causes fire spread to another part of the building or nearby connected building. The cavities should be protected using the compartmentation or containment by building up wall barriers up to the roof top.

19. **Protected Areas**
It is important to have a protected area within the school boundary or even in a complex school buildings. The protected areas are normally being used as a refuge areas or recovery areas during any emergency or during the recovery period. This matter is very seriously considered because of the climatic effects which are unpredictable or unexpected in the Tropical Region. A place of shelter from hot sun, cold wind or cold rainy season is
helping to ease the difficulties in terms of finding a temporary place to help the victims of any fire emergency in this case. Another reason that a protected areas are needed because the public housing is normally far away from the school compound. Multi-purpose buildings which can accommodate a large number of people will be used as the refuge area for any kind of emergency. These include the gymnasium, mosque, hostel, etc.

20. **Smoke Control and Movement.**

It could be in terms of building materials that are producing less smoke or smokeless and the building design should be able to incorporate with the building location against the wind direction and also stack effect which could caused spreading of fire and obstruction to the occupancy eye views or respiratory system (breathing capability).

The evaluation check list is used for assessing and evaluating the level of acceptable fire safety standard in a school building which is based on the given "NORM" by the Building by-laws 1984(4) and also discussion within the first Delphi Group (refer Appendix 5.0: Part E of Chapter 5). There are about 35 fire safety components for the school establishment. However, it was summarized and rearranged into the initial list of twenty fire safety components which are described as follows:-

<table>
<thead>
<tr>
<th>Components</th>
<th>11. Smoke Movement and control</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Building occupants</td>
<td>- Factors affecting smoke movement</td>
</tr>
<tr>
<td>- Students</td>
<td></td>
</tr>
<tr>
<td>- Visitors</td>
<td></td>
</tr>
<tr>
<td>- Teachers / Staffs</td>
<td></td>
</tr>
<tr>
<td>2. Fire Fighting (Manual)</td>
<td>12. Internal Environment</td>
</tr>
<tr>
<td>- Portable extinguishers</td>
<td>- Activities and functions</td>
</tr>
<tr>
<td>- Fire Blanket</td>
<td>- Comfort and facilities</td>
</tr>
<tr>
<td>- Sand / water buckets</td>
<td>- Ergonomics</td>
</tr>
<tr>
<td>- Signs and notices</td>
<td>- Open areas</td>
</tr>
<tr>
<td>- Public Addresses System</td>
<td>- External building</td>
</tr>
<tr>
<td>- Emergency Telephone</td>
<td>- Activity</td>
</tr>
<tr>
<td>4. Building</td>
<td>14. Furnishing/Furniture/Appliances</td>
</tr>
<tr>
<td>- Layout or distance separation</td>
<td>- Interior finishing</td>
</tr>
<tr>
<td>- Materials</td>
<td>- Electrical goods</td>
</tr>
<tr>
<td>5. Fire Prevention</td>
<td>- Surface materials</td>
</tr>
<tr>
<td>- Security and Supervision</td>
<td></td>
</tr>
<tr>
<td>- Regulations and disciplines</td>
<td></td>
</tr>
<tr>
<td>15. Means of Escape</td>
<td></td>
</tr>
<tr>
<td>- Emergency lighting</td>
<td></td>
</tr>
<tr>
<td>- Direct External Egress</td>
<td></td>
</tr>
</tbody>
</table>

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All of the listed components and with their definitions are then being analysed several times before they are finalised into fourteen major components. Generally the changes and evolution of the initial list of components results from the definition given for each of the component and the identification of some of the components as sub-components of other components. The definitions are given in the second list of Appendix 7.0. A comparative study has been done between the Building by-laws(4) and the Draft British Standard Codes of Practice(5) for the fire safety components requirement in a building. So, the final fourteen fire safety components for schools buildings have been rearranged according to the fire growth graph are as follows:

<table>
<thead>
<tr>
<th>FIRE SAFETY COMPONENTS FOR EDUCATIONAL ESTABLISHMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Building Occupants</td>
</tr>
<tr>
<td>2. Fire Prevention</td>
</tr>
<tr>
<td>3. Preparedness for Fire Emergency</td>
</tr>
<tr>
<td>4. Internal Environment</td>
</tr>
<tr>
<td>5. Services</td>
</tr>
<tr>
<td>6. Detection</td>
</tr>
<tr>
<td>7. Communication and Alarm</td>
</tr>
<tr>
<td>8. Egress</td>
</tr>
<tr>
<td>9. Fire Fighting</td>
</tr>
<tr>
<td>10. Protected Areas</td>
</tr>
<tr>
<td>11. Auto Suppression</td>
</tr>
<tr>
<td>12. Smoke Control</td>
</tr>
<tr>
<td>13. Building Structure</td>
</tr>
<tr>
<td>14. External Environment</td>
</tr>
</tbody>
</table>
7.3.2 What is CHECK LIST?

Watts(8) stated that check lists is a common accessory of fire safety with listed hazards and recommended practices. Check lists represent a table of contents identifying complex fire safety concepts with a few words. The check lists comprise valuable tools for identification of fire risk factors. However, they do not distinguish among the importance of these factors. In general, check lists are useful in many situations where it is important to think of everything that could be relevant to building quality and looking at the factors or components that can influence building performance. In this case the fire safety in buildings. Even though, it is described fire safety but in actual fact it also involved fire risk, fire hazard and anything that can affect its performance. The Centre for Building Performance Research (CBPR) suggested that the check list can be used in four ways(6):

a). For design and design audit work.
b). For briefing and programming work
c). For planning and evaluation
d). As a framework for a database.

The check list by its nature cannot deal with interactions between its contents at any level of detail. But the interactions among the fire safety components are undertaken by a check list which has been developed using the points scheme approach in the next chapter. There are 6 attributes that has been suggested by the CPBR Check list (6) which in some ways do relate and contribute to the components inspection check list.

7.3.3 The Usage of The Components Performance Appraisal Check List

With the support of the Delphi Group discussion using the Reminder questionnaire (Refer to Appendix 7.1) on the fire intervention techniques, a set of detailed check lists on building types, fire safety components and sub-components have been produced. Each of the fire safety components is being defined to establish the coverage area that a particular component is focused on or related to. The check list is covering the detailed requirements of each component which helps to
broaden the mind of an evaluator by just reading through all the requirements and the intervention sequence before making any fire audit of the building or area. This check list is divided into 3 parts: - (refer to Appendix 7.0)

1. The first list is to identify the fire safety components and sub-components within the particular types of building categories and areas. This list has gone through alteration and rearrangement a couple of times to ensure that the Norm that the fire safety components are covering the whole building in terms of fire safety performance.

2. The second list is the definition of each of the fire safety components which describes the extent of coverage of each component in order to avoid over lapping or redundant work and repetition in assessing component performance.

3. The third list is the detailed appraisal check list to identify the cause of any failure or potential lost contribution in the overall performance of the fire safety components which results in the level of acceptance i.e. : not acceptable includes very bad (need system installation), bad (need replacement system or system maintenance), and acceptable includes good, very good and excellent.

There are also tree diagrams given for each component as a summary of how the component is supposed to be approached and on what to focus. This is stated in the guidelines notes (Appendix 7.2) for each of the components after the explanation for each of the boxes within the scope of the components is provided. A complete set of the performance appraisal check list covering all the fourteen components are given in the Appendix 7.2. There are two divisions of appraisal checklist which have been formed; (a) one is without point scheme and the other division (b) is with points scheme which is still under development. The example of the audit or appraisal assessment on one of the fire safety component is given as follows: -
This check list is concentrated on the formation of the appraisal without points scheme. The contribution of discussion and agreement on the questions set for Delphi Group1 has resulted in the fourteen components being arranged based on their intervention techniques and also the grouping of areas into several building types. The discussion from the Reminder Part of the questionnaires for Delphi Group1 gave the agreement of the relevant sub-components for each of the fire safety components that need to be examined closely during the appraisal tasks.

Example:-

<table>
<thead>
<tr>
<th>Fire safety components:</th>
<th>Building Categories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Component</td>
<td>Sub-component</td>
</tr>
<tr>
<td>3. Fire Prevention</td>
<td>A</td>
</tr>
<tr>
<td>Arsonist-</td>
<td></td>
</tr>
<tr>
<td>Supervision and security</td>
<td></td>
</tr>
<tr>
<td>- Locks</td>
<td></td>
</tr>
<tr>
<td>- Grills</td>
<td></td>
</tr>
<tr>
<td>- Fences</td>
<td></td>
</tr>
<tr>
<td>- Officers</td>
<td></td>
</tr>
<tr>
<td>- House hold and decoration- not to use the decoration lights</td>
<td></td>
</tr>
<tr>
<td>- Over loaded plug</td>
<td></td>
</tr>
<tr>
<td>- Storage of flammable liquid, gaseous or substances/items.</td>
<td></td>
</tr>
<tr>
<td>- Using the non-combustible materials</td>
<td></td>
</tr>
</tbody>
</table>

List of Building Areas

Division of Areas into 5 different Categories:

A. Academic Buildings (I)
B. Academic Buildings (II)
C. Accommodation or Hostel
D. Administration and Management Buildings
E. Other Buildings

A. Academic Buildings (I):

- Classroom
- Computer room
- Library
- Resource Center/ Technology Media
(Continued)

### B. Academic Buildings (II):

<table>
<thead>
<tr>
<th>Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
</tr>
<tr>
<td>Workshop</td>
</tr>
<tr>
<td>Home Science</td>
</tr>
<tr>
<td>Co-operative shop</td>
</tr>
</tbody>
</table>

### C. Accommodation or Hostel Buildings:

<table>
<thead>
<tr>
<th>Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dormitory</td>
</tr>
<tr>
<td>Single room</td>
</tr>
<tr>
<td>Pantry room</td>
</tr>
<tr>
<td>Sick Bay</td>
</tr>
<tr>
<td>Warden flat</td>
</tr>
</tbody>
</table>

### D. Administrative and Managerial Building:

<table>
<thead>
<tr>
<th>Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Office</td>
</tr>
<tr>
<td>Staff room</td>
</tr>
</tbody>
</table>

### E. Other Buildings:

<table>
<thead>
<tr>
<th>Building</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosque</td>
</tr>
<tr>
<td>Canteen</td>
</tr>
<tr>
<td>Dining hall</td>
</tr>
<tr>
<td>Gymnasium</td>
</tr>
<tr>
<td>Assembly Hall</td>
</tr>
</tbody>
</table>

The division of building areas has been referred to the Delphi group discussion in Chapter 5 where five categories has been agreed as above. However, the above division has been slightly changed to consider only indoor activities and as a result some of the building areas are categorized within the other buildings category.
7.3.3.2 **Second Check List:**

This part of the appraisal check list is more concerned with the definition of each of the fire safety components to be evaluated. It is used to assist the evaluator to limit the evaluation scope of coverage to only certain extend required for each of the components. So the evaluator knows what to look for during the appraisal or inspection of the areas or buildings.

Example:-

<table>
<thead>
<tr>
<th>Component</th>
<th>Sub-component</th>
</tr>
</thead>
<tbody>
<tr>
<td>3. Fire Prevention</td>
<td>- Arsonist- Supervision and security</td>
</tr>
<tr>
<td></td>
<td>- Locks</td>
</tr>
<tr>
<td></td>
<td>- Grills</td>
</tr>
<tr>
<td></td>
<td>- Fences</td>
</tr>
<tr>
<td></td>
<td>- Officers</td>
</tr>
<tr>
<td>Management of combustible materials:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- House hold and decoration</td>
</tr>
<tr>
<td></td>
<td>- Use of non-combustible materials</td>
</tr>
<tr>
<td>Management of potential source of ignition</td>
<td>- Over loaded plug, switches or electrical appliances</td>
</tr>
<tr>
<td>Storage of flammable liquid or chemical substances.</td>
<td></td>
</tr>
<tr>
<td>Storage of flammable gaseous</td>
<td></td>
</tr>
<tr>
<td>Storage of flammable and high specific heat items</td>
<td></td>
</tr>
</tbody>
</table>

Note: In this case fire prevention is the component that deals only within the scope of preventing ignition, management of fuel available and preventing fire cases from becoming worst such as the effort to make sure that fire is prevented from being ignited or spreading out. It is also considered as part of the fire safety management and administrative effort involving the organization of fire safety requirement.

Note: Arson is being considered as a part of the component for fire safety because its main motive in causing fire can be vary from individual aspect to the political aspect which normally involved discomfort, revenge, unsatisfactory and disagreement on certain issues.

7.3.3.3 **Third Check List:**

The following is only an example of one of the fire safety components to be inspected in terms of its performance appraisal. This part of the check list is being assisted by a guidance notes which elaborated each of the boxes that need to be selected during the process of evaluating or appraising. There are two versions of this check list; one with contribution points which is still under process of development and the other without points. The latter is being considered in this whole chapter about the performance appraisal check list.
Once the whole steps of appraisal requirements in the given guidance notes and check list of a fire safety component has been undergone, the evaluator is expected to be able to give an overall view or perception about the level of safety performance that it could contributes or deemed to achieve during emergency or when it is operating.

Example:-

### Component 3: Fire Prevention

#### Activity Within Space

3.1 Tick "✓" in the following box: (Only choose one building area at a time)

<table>
<thead>
<tr>
<th>Building Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Room</td>
</tr>
<tr>
<td>Resource Center</td>
</tr>
<tr>
<td>Library</td>
</tr>
<tr>
<td>Mosque</td>
</tr>
<tr>
<td>Pantry Room</td>
</tr>
<tr>
<td>Sick Bay/Room</td>
</tr>
<tr>
<td>Laboratory</td>
</tr>
<tr>
<td>Assembly Hall</td>
</tr>
<tr>
<td>Computer Room</td>
</tr>
<tr>
<td>Warden Flat</td>
</tr>
<tr>
<td>Workshop</td>
</tr>
<tr>
<td>Gymnasium</td>
</tr>
<tr>
<td>Classroom</td>
</tr>
<tr>
<td>Prayer Room</td>
</tr>
<tr>
<td>Home Science</td>
</tr>
<tr>
<td>Dining Hall</td>
</tr>
<tr>
<td>Study Room</td>
</tr>
<tr>
<td>Store Room</td>
</tr>
<tr>
<td>Staff Room</td>
</tr>
<tr>
<td>Canteen</td>
</tr>
<tr>
<td>Toilet</td>
</tr>
<tr>
<td>Cooperative Shop</td>
</tr>
<tr>
<td>General Office</td>
</tr>
</tbody>
</table>

3.2 & 3.3 Tick "✓" in the following box:

<table>
<thead>
<tr>
<th>Enclosed Area</th>
<th>Open Area</th>
<th>Semi Enclosed</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Risk</td>
<td>High Risk</td>
<td>High Risk</td>
</tr>
<tr>
<td>Medium Risk</td>
<td>Medium Risk</td>
<td>Medium Risk</td>
</tr>
<tr>
<td>Low Risk</td>
<td>Low Risk</td>
<td>Low Risk</td>
</tr>
</tbody>
</table>

3.4 Entry

<table>
<thead>
<tr>
<th>Easy Access</th>
<th>Need Passes</th>
<th>No Entry</th>
<th>Authorized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

3.5 Supervision

<table>
<thead>
<tr>
<th>C.C.T.V</th>
<th>Guard</th>
<th>Warden</th>
<th>Technician</th>
<th>Teacher</th>
<th>Leader</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

3.6 Security

<table>
<thead>
<tr>
<th>Locks</th>
<th>Grills</th>
<th>Fences</th>
<th>Duty Guard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
3.7 Tick "√" in the following box:

<table>
<thead>
<tr>
<th>Flammable Items</th>
<th>Liquid</th>
<th>Gaseous</th>
<th>Solid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Proper Storage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper Labeling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Involve Naked Flame</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Proper Handling</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decoration lighting</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trained Assistant (Avail)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.8 Maintenance

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric cable/wiring</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire Safety Equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposable items</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3.9 Other (consideration)

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over loaded plug</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Switch Left</td>
<td>On</td>
<td>Off</td>
</tr>
<tr>
<td>Combustible Materials</td>
<td>Over 50%</td>
<td>Less 50%</td>
</tr>
</tbody>
</table>

Overall assessment rank order:- 0 1 2 3 4 5
(Circle any one of them)

7.3.3.4 **Guidance Note:**

It is clear that the following are explanations of how each component is being assessed or inspected or even appraised.

Example:-

**Component 3: Fire Prevention**

3.1 The **building areas** within the box need to be chosen only one at a time during the evaluation so that every space is being evaluated individually. This way will assist the administrative personnel to defined the problems in terms of fire safety and tackled them according to the priority of the areas and its' importance. Hence, the constraint of budget in providing the fire safety requirement of a space or building (in total) can be allocated accordingly depending on the availability of the budget.

Note; The priority and importance of the areas within the school or educational establishment can be referred to the discussion given by the Delphi Group.
3.2 The area then must be categorized under the type of enclosure such as:

a. **Enclosed area** - is an area which have no direct opening to the external environment except doors and windows. Normally the windows and doors are closed for air-conditioning purposes to create a controlled environment within the space throughout the time.

b. **Open area** - is an area which widely exposed to the external environment and not protected by any structures (vertically) against external influence. For example the open car park, tennis court or playing field.

c. **Semi-enclosed area** - is an area which has structures protecting from external environment but can still be influenced by the external temperature or noise particularly when the internal environment is not fully enclosed at all time. i.e. the windows and doors are widely open throughout the period for ventilation purposes or the wall is only built half way up. Usually in Malaysia, the semi-enclosed areas are those with natural ventilation or fan with no air conditioning system.

However, there are also some areas which are **dual functions** either to be enclosed or semi enclosed depending on the availability of power supply to operate the air conditioning system or the activities under taken. In this case, do consider the areas to be enclosed areas.

3.3 **Level of Risk**

i. **High Risk**

   a)- Flammable liquid/ gaseous/ substances /
   b)- Combustible materials more than 50 % occupying or kept within the area.
   chemical more than 50% involved with the main activities within the area.
   (c)- More than 50% electrical appliances are being used for it's activities within the area.
   - Example: cooking/ chemical experiment/ welding etc. or Having two/ all three sources (a)(b) and (c). (canteen, laboratory, dining hall and store room, dormitory)

ii. **Medium Risk**

   (a)- Flammable liquid/ gaseous/items/ chemical around 20% to less than 50% involved with the activities within the area.
   (b)- Combustible materials ; between 30% to 50% occupying or used or kept within the area.
   (c)- Less than 50% up 20% of the electrical appliances being used for it's activities within the area.
   - Example: Staff room, classroom, Assembly hall or having one of the three sources (a) or (b) or (c).

iii. **Low Risk**

   (a)- Flammable liquid/ gaseous/items/ chemical less than 20% involved with the activities within the area.
   (b)- Combustible materials ; less than 20% occupying or used or kept within the area.
   (c)- Less than 20% of the electrical appliances being used for it's activities within the area.
   - Example: offices. or having insignificant amount of one of the three sources of fire threat (a) or (b) or (c).

Try to check whether the following factors that may cause fire and explosion, exist within the area which also contributing to the level of risk.
The Cause of Fire and Explosion

a. Electrical  
io. Exposure  
j. Spontaneous Ignition  
k. Combustion sparks
b. Smoking  
l. Chemical reaction

c. Incendiary  
m. Mechanical sparks
d. Over heated materials  
n. Static sparks
e. Hot surface  
o. Lightning

f. Open flames  
p. Molten substances
g. Cutting and welding
h. Friction

(refer to Data Compiled by Factory Mutual Engineering Corporation 1983-1987)

or refer to the **Type of Threat Within the Educational Premises Graph** produced by the questionnaire results. As the educational premises considered by the Building regulation as a low risk building, therefore the types of risk are measured only using three major threat: Electrical appliances, gaseous and chemical.(refer to Appendix 7.3)

3.4 The third box is simply to say that the type of **supervision** given within the specify area while the **occupants** carrying out the **activities**.

3.5 The **entry** is basically referred to the **types of accessibility** of the occupants in and out of the area during or after the conducted activities.

3.6 The **security** of the area should be considered at all time particularly to avoid arsonist attempts. It is more towards **physical provision**.

3.7 Now we are looking at the **storage and the management** of the **flammable items** within the area.

3.8 **Maintenance** is more focused on the **electrical appliances** that are normally being provided or used while conducting and occupying the area.

3.9 **Other** consideration will be more towards the proper way of using the **electrical appliances** and connections. Besides, the usage of **combustible materials** are more on its storage and layout within the area.

Note: The underline word are emphasizing the limitation of one looking at the relevant boxes of the check list for evaluation purposes. And the number on each paragraph is referring to the sequence of the boxes within the check list and the same for the bold words on the paragraph.

The contribution towards techniques of intervention are:

a) Education and training. Code of Conduct which provides guidelines and rules that one should follows while involving with the activities conducted within the premises.

b) Environmental monitoring in terms of the possible risk and fault by human or appliances and services.

c) Passive Fire Control. The materials used and the combustibility or flammability of each items. These are important to reduce the chance of fire spread.

d) Detection System (the presence of human )

e) Alarm or Warning System and Communication
The contribution towards tactics are:

a) Improve fire safety management (Fuel and Source of ignition)
b) Reduce the severity of fire accident (fire spread/ explosion)
c) Improve the environment and security level
d) Increase the occupants level of awareness
e) Ensure the risk and safety factors are being considered
f) Ensure the safety of handling and storage of flammable items.

The contribution towards objectives are:

a) Life Safety
b) Property Protection
c) Education Continuity
d) Education Environment
e) Public Anxiety
f) Economy

Diagram 7.1: Fire Prevention Assessment Steps
This chapter is presenting the check list to be used by the non-professional and professional evaluator for fire safety management which covers more detailed requirements in terms of a particular fire safety components. It is more towards auditing and maintenance of the fire safety systems available within the building areas. The check list is also apart of the whole evaluation process but it is taken to be a step forward than the overall evaluation that has been done by professionals using the points scheme methodology in chapter 8. This check list contribution is given by the first Delphi Group members whom are considered to be the representative of lay-man and semi professionals or probably trained evaluators for the educational establishment.

7.4 Carrying Out The Appraisal Assessment

Eventhough, the guidance notes have already given the details on how to undertake the inspection assessment using the check list, yet each of the component guidelines can be generalised into common procedure. The procedure in carrying out the inspection using the check lists can be done by referring to the steps in doing the risk assessment for workplace which is suggested by the Home Office (14). Basically, the evaluators will have to know the principles of the fire triangle which consist of fuel, oxygen and heat. And the first few things to be considered in assessing the areas are:-

a. The work or activity;
b. The materials stored or used;
c. The contents of the workplace, including furnishings;
d. The construction of the workplace including internal linings;
e. The size and layout of the workplace; and
f. The number of people who are likely to be present, whether as occupants or otherwise i.e. visitors or members of the public, and their ability to respond to an emergency.

Since the check list approach is referring to the fire growth graph (Chapter 6: Diagram 6.1), all the intervention techniques has already been covered which includes the building structures, the presence of human life, the building contents and also the fire safety components where they are indirectly related to the above
considerations. Each area within a building should be evaluated using all the fourteen check lists only if they are installed or found within the space. By using the check lists, the following information can be identified:

b. The items at risk especially the building occupants such as the staffs, students etc.
c. Fire safety provisions that helps to remove or reduce the fire hazards.
d. Decision on the level of fire safety adequacy if there is a need to improve or maintain.
e. The checklist itself is a form of record of information.
f. The inputs are to be used for preparing to face the emergency.

7.4.1 Performance Appraisal and Risk Assessment

The component performance appraisal (inspection) check list can be considered having a parallel use as the risk assessment but only covers in detail the fire safety components in terms of the contributory events such as equipment failures, design limitation, human errors, hazards and associated activities. A risk assessment can be very simple, common sense process for a small undertaking, where the number of hazards are few and their potential consequences are well understood. Similarly, all that may be required is a judgment whether current protection or precautionary measures are adequate to reduce the risks to the habitant, property and continuation of education or other safety objectives to an insignificant level. It was suggested by Au S.Y.Z et.al(15) that the overview process of a simple risk assessment consists of four main stages:-

1. Identification of hazards - hazard can be regarded as something which has the potential to cause harm including injury or death to people, damage to property, discontinuation of mission or activities, pollution to the environments, economic losses and build up the public anxiety upon the capability of the administrators, etc.
2. **Risk Estimation** - this is to estimate the likelihood and consequences of the hazards identified which involves the study of loss impact and level of severity.

3. **Risk Prioritisation** - this involves deciding on the relative importance of the hazards identified. It can be used in terms of risk rating numbers or professional judgment.

4. **Identification of action/measures to minimise risk** - this is to determine the remedial actions or measures required in order to minimise the risk facing by the occupants and properties or the whole organisation inspite of fire loss impact.

In this study, the identification of hazards, risk estimation and risk prioritisation has been undertaken by the set of questionnaires sent to the building occupants and also Delphi Group (refer to Chapter 4 and 5) where the types of fire threat is already notified within the schools areas, the priorities of the areas and the study of loss impact expected also has been established. Whereas, the identification of action or measures to minimise risk may go along with the used of the appraisal check list and decision making by the professionals.

The appraisal is using rank order appraisal method which needs to be very clear in the objectives that each of the components can contribute. Therefore, a thorough study and understanding of the fire safety components are parts of the required criteria expected from the evaluator. The tactics and objectives of the evaluation procedure which involve this performance appraisal check list are elaborated in Chapter 8.

**7.4.2 Appraisal System and the Development**

- Ensure the types of initial training needed for every evaluator are suitable for the evaluator to be able to make decisions to achieve the acceptable level of safety performance for every areas being assessed or appraised.
• Feedback on the performance check list can help to ensure that the required performance is maintained.
• Appraisal also can indicate areas, services or safety systems installed within a building where development or alteration is required.
• Help to promote the effective fire safety system in terms of long term and short reliability especially during emergency and also may assess the cost effectiveness of proposed systems.

The appraisal check list can contribute towards:-

a) An opportunity to go on learning about safety, risk and hazards aspects within the workplace in the schools.

b) The maintenance of the level of safety required and the increase in the level of responsibility of the selected maintenance officer(s).

c) Using the checklist to help the evaluator and management officers to make some decisions and use discretion on the level of safety required. The performance feedback could assist the evaluator and management or authority to decide for desirable future development or requirement.

d) The appraisal check list providing a form of record system and to be able to conduct the appraisal in a systematic way.

e) It's overall performance to enable to predict the level of loss impact expected if a proper solution is not given priority.

However, some kind of performance appraisal interviews probably will need to be carried out in order to obtain data which might not be available, such as the human behaviour and response towards fire emergency. Unless the statistical data on that matter is available. The level of occupants fire safety awareness that has been undertaken in Chapter 4 is the example of data which need to be obtained in order to take into account all the possible performances for a comprehensive evaluation scheme involving the occupied buildings.
7.5 Performance Appraisal

Rank the component performance assessment against fire within the area in the order of 0 to 5, where :- 0 = no danger of fire

<p>| | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>High Threat</td>
<td>Average Threat</td>
<td>Less Threat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Risk</td>
<td>Medium Threat</td>
<td>Low Risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Safety</td>
<td>Medium Safety</td>
<td>High Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly Vulnerable</td>
<td>(Vulnerability)</td>
<td>Less Vulnerable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Diagram 7.2: Performance Appraisal Ranking Reference

The rank order is given by the evaluator based on his/her perceptions after considering the details of the components' performance including the related sub-components. The evaluators or trained building maintenance officers will have to be able to assess the severity of fire accident if it has happened within the particular area being assessed. The evaluation can be in terms of the level of safety provided, lives or properties at risk or the vulnerability of the space, area and contents against fire i.e. the fire spread to the next compartment, the contain of combustible fuels within the area or the damage expected to be countered. All the feelings, thoughts and concerns can be built up within the mind of the evaluators by understanding the behaviour of fires, human responses, activities, the questions to be asked where the examples of the questions are given in Chapter 6: Appendix 6.2, the guidance notes and the inspection check list itself all help to achieve the purpose of making them sensitive and critical about the level of risk or danger, vulnerability of the space and its contents and safety expected within the assessed areas. And therefore, be able to make decision in giving the appropriate rank order of the fire safety components performance contributions.
7.6 Evaluation Inspectors or Personnel

The evaluator should be given a training programme on how to deal with the evaluation process and also with a good understanding about the whole objectives and tactics of fire safety. The evaluator can be fire brigade officers, private fire safety consultants, building inspectors of local authorities or in-house, insurance company surveyors or in this case could be the Ministry of Education Officers.

7.6.1 Staff Training

This stage of evaluation can be done by the trained fire safety officers of the same organisation i.e. Officers from the Ministry of Education, or the selected maintenance officers and even the fire brigade officers. A set of training programmes should be conducted intensively amongst the selected personnel regarding fire safety for the schools and hostels. This training are very important for the selected staffs before they are able to carry out inspections on fire safety within the schools without the presence of fire safety engineers or consultants. This will probably help to reduce the cost for consultancy where the professionals may only be involved at the confirmation stages on the level of safety of the schools areas after being checked by the trained school staffs or maintenance officers.

References for conducting staff training programme on fire safety can be made to the Research Report on Managing Crowd Safety in Public Venues(7). Staff need to be carefully selected and trained to ensure that they can fulfill their defined roles and responsibilities by having the basic physical, mental and personal attributes necessary to carry out the tasks allocated to them. Among the steps to carried out the staff training programme are as follows:-

1. Set a training programme organised by the fire brigade or fire safety consultant.
2. Select the appropriate staff member to be trained.
3. Make the check list available for the use of appraisal or review and assessment process(es).
4. Clearly state the goals and objectives to achieve from the appraisal or review process by using the check lists.
5. Ensure that the appraisal or review or assessment task is incorporated with the evaluation of performance wherever possible against standards or target. The in-house maintenance officer if present would be very helpful to be approached.

6. Understand the performance of the fire safety components and detect the changes within the area in terms of activities, occupancies and function.

7. Ensure that the review includes consideration of management aspects such as policy, training, communication etc., as well as plans, procedures and control measures used in the operation of the building area / venue.

8. Able to make the decision on the contribution appraisal performance values of the overall fire safety acceptability standard of the particular component within the specified area.

The scope of this evaluation is to cover the safety performance appraisal for each component which is then accumulated to form the overall safety of that particular area. All the safety performance of the areas involved within a building can then be accumulated again to give the overall condition of the building safety performance.

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**Diagram 7.3: Fire Safety Performance Appraisal**

<table>
<thead>
<tr>
<th>LEVEL OF APPRAISAL</th>
<th>SAFETY PERFORMANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Areas within a building</td>
<td>Level of acceptability of the particular area(s)</td>
</tr>
<tr>
<td>(+) Areas Category</td>
<td></td>
</tr>
<tr>
<td>(+) Building Category</td>
<td>Level of acceptability of the building category</td>
</tr>
<tr>
<td>(+) The whole School Buildings</td>
<td>Level of acceptability of the whole school</td>
</tr>
<tr>
<td>(+) Schools within the same District or State</td>
<td>Level of acceptability of the schools within district or state.</td>
</tr>
</tbody>
</table>
However, by referring to Diagram 7.3, the fire safety performance appraisal have several level of safety appraisal to achieve, begins with the single area within a building areas category then the building category and then followed by the whole school buildings until the evaluation of the schools within the same district or state. This shows that the need of having standardised fire safety evaluation appraisal scheme for the educational establishment is important.

7.6.2 Professionals

A much more detailed evaluation in terms of engineering application can also be done by the installer or maintainers or fire safety engineers. This requires a comprehensive knowledge of the manufactured products of the safety components and also its specification from the manufacturer of that particular systems. Normally the fire safety certification is given to the buildings that has been inspected by the approved fire consultancies or the fire brigade which has been given the authority to do so, especially involving the government buildings such as schools. This is where the points scheme contribution that needs to be developed became important so that the technical personnel such as engineers can explain well using the contributory number to the non-technical personnel, i.e. the administrators, managers about the performances of the fire safety system available compared to the existing risk or hazards faced by that particular areas or buildings. Here, the involvement of making decisions will determine the level of fire safety that needs to be maintained or to be replaced with new systems in the trade-off applications or improvements to be undertaken.

7.6.3 Designing Checklist and It's Functions

This is important to enable a measure the effectiveness of the check lists. Among the important things to be considered and recognised by the evaluation check list designers are the key functions of the check lists, the assessment requirements and the characteristics of a good check list. It was listed by Baird et. al (6) in the CBPR Checklist that the evaluation (appraisal, inspection and maintenance) check lists key functions are:-
i. Memory jogger - a thinking aid, a design aid and a tool to assist the evaluator and ensure a comprehensive approach to the evaluation task.

ii. Efficiency - the check list should be able to provide enough information and covers a wide range of things within a visit which save time for the evaluator from repeating the task.

iii. Recording - has a target and space for the particular place or category against which to record observations, notes and measurements.

iv. Team work - the items are grouped in a common framework using a consistent terminology to avoid misunderstandings about parts of building are being discussed.

v. Prompter - it is not the end of the evaluation but also can act as a prompt for identifying and dealing with other things that may be important to the activities of the organization.

The assessment requirements of the check list should be accurate and cover a comprehensive knowledge of fire safety. Other characteristics or design rules for checklists should be convenient, legible and balanced(6).

7.7 Trade-Off: Concepts and Application

It is recognised that two different protection disciplines may provide the same, or similar, end objective by using different methods to reach that objective. It was suggested by Ramachandran(9) that the trade-off between safety measures can be evaluated on the basis of equivalent effectiveness or performance. This is due to the development and suppression of a real fire which involves uncertainties of the random nature of factors affecting the spread of fire and smoke, behaviour of people and the reliability and performance of fire protection system described by Watts(10). The normal use of trade-off in the probability studies of fire protection systems or the fire safety components usually involves some considerations on the types of probabilities for fire growth, building size, compartment size, fire resistance, barrier failure and evacuation time.
The types of probabilities can be categorised into 4 (11):

i). The probabilities of extinguishment,

ii). The probabilities of confinement,

iii). The probabilities of fire spreading beyond contents and involving barrier of the compartment and

iv). The probabilities of flashover or fire spreading beyond the room.

Next are the stages of fire growth which should be recognised, is the potential of fire to ignite the surrounding fuel within the origin room to the next based on length of time. Fire could possibly grow at a steady rate or increasing exponentially with duration of burning. The initial rate of growth would depend on the material first ignited (12). Ramachandran (11) also wrote that the building maximum size with basic fire protection can be prescribed to an acceptable level for the maximum damage subject to a maximum height depending on fire brigade capability. The basic compartment size can be determined with the consideration of property damage, life safety and fire brigade capability factors.

Another method to look at the trade-off concept which can help reveal the most appropriate method for a given situation is using an appraisal of the technical parameters such as the components. It involves the assessment of the technical suitability of alternative proposals against a pre-determined standard solution based on two fronts, reliability and availability (13). ‘Reliability’ provides a qualitative measure of the ability of a concept to reliably and appropriately meet the objective set, whereas ‘availability’ is a measure of the likelihood of the concept being ready to meet the objective when required to do so. This would include consideration of maintenance requirements, of local constraining factors and of the local culture in ensuring that the concept remains fit for purpose. The assessment should be based on the current circumstances and not on may be’s’. Follow up exercise could then quantify a cost/benefit case to bring forward the trade-off concept to an acceptable level.

The contribution points of each components for example, if the total structural contribution points is supposed to be 6, but if the result of the assessment is only 4 for structural, then other components which are contributing higher points such as having the benefit of sprinkler systems in limiting fire spread by the fire suppression
component where the points is 7 instead of 5. Then the extra 2 contribution points could probably be the best solution for the structural deficiency, to make it to an overall acceptable level. The following Diagram 7.4 of components expectation performance merged with the fire growth curves through the predictive duration of the fire life cycle could assist the individuals a better understanding of the decision making process taken by the professionals.

Paul Bryant (13) stated that the protected building or area in terms of fire safety is having an optimum level of protection where the risk is satisfactorily protected and an appropriate level of resource such as time and money have been applied to reach the protection goal. However, the overprotection could be made when a strategic plan has been drawn up, and then amended by others and then added to and so on. Overprotection could mean additional and abortive planning and design costs, additional costs for the purchase and installation of equipment, constructions, etc. and the longer term costs associated with maintenance. The additional unnecessary complexity could lead to lower total availability and reliability of the systems and may increase the instance of false alarms.

Diagram 7.4 shows that all the fourteen fire safety components are being merged into the fire growth graph only to be used as a guidelines in evaluating the components performances in a building of fire origin. Most of the components are expected to perform according to the arrowhead lines which represent each of them. However the lines seems to be overlapping each other; this is to show that the safety components should be performing to a certain extend from the pre-fire stage until it is fully activated during the fire growth stages. The component performance expectation should not be affected or damaged in the fire emergency and performing the same level of efficiency if the fire is managed to be extinguished before it reaches the particular point in the fire growth graph.
Fire Safety Components
1 -- Building Occupants
2 -- Preparedness for Fire emergency
3 -- Fire Prevention
4 -- Internal Environment
5 -- Services
6 -- Detection
7 -- Communication and Alarm
8 -- Egress
9 -- Fire Fighting
10 -- Protected Areas
11 -- Auto Suppression
12 -- Smoke Management
13 -- Building Structural Response
14 -- External Environment

Fire Growth Stages
A ---> Pre Fire
B ---> Incipient Stages
C ---> Fire Threat
D ---> Fire Growth
E ---> Fire Fully Developed
F ---> Fire Decay
G ---> Fire Extinguished

Diagram 7.4: Fire Safety Components Performance Expectations Merge With Fire Growth Graph
There are actually two types of check list, one without the points and the other one with points corresponding to each of the boxes. The number given to each of the boxes in the check list of the fire safety components (Appendix 7.2) can be totaled up representing the contribution values for the specific items and the round up of the total values for the particular component is representing the value of fire safety components installed within the area of concern. These values can give the overall performances of the system or components in detail if it is found to be the main hazard contributor to the area or building. So, the rest of the points can also help the maintenance officers and engineers to tackle the specific problems in a more focused environment. It is also a method to put all the related fire safety components in term of mathematical number as a problem solution. The points given can be of any number (agreed by discussion or derived from Delphi Group) which are then it’s total sum of that component is multiplied by the contribution factors derived from the points scheme evaluation check list to come out with a result for that components performance level of acceptability. This part of the study has not been able to tackle this aspect thoroughly and it is a part of the suggestion for future research. Refer to Diagram 7.5.

In general, the guidance notes in Appendix 7.2 are provided as a tool to make the evaluator(s) understand the need(s) of each system that is being assessed, for example:-

a) The limitation of the check list.

b) How to use the check list.

c) What kind of expectation from the answers given by the check lists.

d) A quick references in auditing the fire safety components and related parts of the building by looking at the diagrams provided. One can see the things to be assessed using the check list more easily with the help of the diagrams.

e) It is also being used in the points scheme evaluation as a revision note before the risk assessment and analysis is undertaken.

f) It is specifically to be used when carrying out a detail assessment on the parts which contribute towards each of the component performance expectation.
The whole check list of the fourteen fire safety components are produced mainly focus on the individual components and sub components. It does not inter-relate between other components and it is called "Components Appraisal Performance Check List". Therefore, in order to recommend the use of number or points for the above checklist, another part of the check list which is explained in the chapter 8 need to be combined. This is to say that, the appraisal performance check list should come later in the whole evaluation process of the fire safety for educational establishment.

Diagram 7.5: Using the Check Lists : Application Procedure
Fire Safety Audit

Normally, the fire safety audit is being done based on the critical observation of the existing and current condition of building performance and its contents which contribute towards the overall achievement of the fire safety objectives. It does not evaluate non-existing systems within the space but only concentrate on the available system or component performance since the last time they are being assessed or checked. For example, if a door gives 100% performance once it is installed in an area, questions can be asked whether the system or component is still giving the same level of performance i.e.: are there any holes in the door, is the door still being used for the same functions or may be there are no more doors (broken or replaced as a permanent opening) between two areas, is the door locked permanently for security reasons, etc. Assuming that all the components of fire safety is giving 100% safety if everything is taken into consideration than the assessing work for the area should based on the loss impact, vulnerability or threat. Therefore the best performance of an area must be of less risk, less threat, less vulnerability to fire exposures and probably high safety measures. And the worst performances of an area must be of high risk, highly vulnerable towards fire threat and with low safety measures.

Fire audit is actually a detailed maintenance list of all the components and to enable to complete the check list will take twice the time or more compared to the professional evaluation check list. Components should be audited on their own and there is no interaction between the components or system within the space. Therefore the check list produced in the Appendix 7.2 can and should be used by the maintenance officers at schools or the education establishment buildings (in general) to ensure the performance of each of the fire safety components are maintained at the acceptable standard.
7.8.2  Suggested Steps To Audit or Appraise A Building.

i. Visit to the site or building in order to familiarize with the environment and work place within the school.

ii. Write down the priority of the areas to be assessed and confirmed the usage and functions or activities carried out within the areas.

iii. Check with the building regulations and fire safety requirements for the types of building. Understand the specification of each of the fire safety components and study the check list requirements.

iv. Set up a second visit for a closer look at the building and services, including the existing fire safety installation and management.

v. Use the check list to assess in details the function and performance of each of the fire engineering installation system or the fire safety components i.e.: emergency lighting, extinguishers, sprinklers etc.

vi. Establish the class of fire, hazards, risks and safety factors available within the area for example the fabric of the interior furniture, services such as gas line, oil lamps, etc.

vii. Do the audit and assessment or appraisal only on the current fire safety system available.

viii. Decide the contribution points to each of the components being evaluated and sum up all the points to give the overall contributions of performance appraisal of that particular area. Use the points scheme given by professional judgment if available.

ix. Suggest the fire safety engineering approach or system to improve the existing safety situation in that particular area by trade-off or just need a scheduled maintenance work.

x. Give comments of every system suggested to the improvement of the areas safety level or maintaining it's acceptable safety standard.

xi. Find out the costing involved and the construction duration if any of the fire safety systems need to be changed or improved or maintained by dealing with the system supplier, specification and expertise available. Look at the priority and benefits of each of the fire safety system to be installed.

xii. Future recommendation, if required.
7.9 Conclusion

The discussion about the fire safety components appraisal performance check list that has been undertaken in this chapter is generally focused on the selected 14 fire safety NORMs. Each one of the components is being provided with performance appraisal check list which help to determine it workability and performance during any situation through out the life of the building particularly fire emergency. The contributory values given by the evaluator at each end of the component appraisal is only the points of between 0 to 5 (16) Likert scale. The effort of developing the check list and all the considerations that need to be taken is to show that a comprehensive knowledge of fire safety and any other related services and occupants comfort is needed to be able to produce a good check list that is easy to be applied by an evaluator. The evaluator with his/her knowledge comes to a decision on the level of fire severity, safety and risk within the space which is of concern and is focused specifically towards the vulnerability and safety of the area against fire hazards which may result from the deficiency or overprotection of the components being assessed.

This particular appraisal performance check lists are contributing towards four main objectives of the fire safety:-

i. Potential Loss Impact
ii. Criticality
iii. Contextual
iv. Improvement

7.9.1 Potential Impact

The potential loss impact of certain areas has to be assessed in terms of their operational hours, maintainability under taken, continuity of the objectives such as the activity carried out, disturbance from within and surrounding activities or services and dependencies on others. However, the potential impact can only be obtained to the level of the components performances so that the particular fire safety components is always giving 100% output and response exactly the way it supposed to perform and at times when it is needed. These also involve the study
of the areas within the buildings in the educational establishment. The purpose is to classify those areas into an order of different level of criticality in terms of fire risk assessment.

Risk assessment can be described as a systematic approach to assess the risks to safety that may arise from an activity or process. Potential hazards should be identified in a systematic and thorough manner. The hazard identification and risk assessment is important in that it enables steps to be taken to develop a safer environment. Even though fire risk assessment is very important to be carried out as part of the main evaluation process, yet it is not able to cover in detail all of the evaluator functions or tasks that should be understood. The needs of fire risk assessment to the extent of enabling him/her to decide priorities and set objectives for the elimination of hazards. This will help to achieve the reduction of risk and attain a significant level of safety that is required within areas of concern.

7.9.2 Criticality

Assessing the fire safety components within the areas or buildings will need to be done very carefully and in a detailed manner which covers the whole purpose of it's installation. Therefore, questions should be prepared critically and the assessors or maintenance officers should have a critical mind to enable the estimation of the uncertainty of the contribution of each of the components. Any defaults (minor or major) in the performances of the components during the operational period of the buildings or areas have to be tested, detected and repaired. This perhaps will ensure that the components give the maximum output expected during an emergency. The questions set to build up the check list also have undergone a critical development stages so that a comprehensive coverage is shown in the end result of the check list formation.

7.9.3 Contextual

The check list also has been arranged according to the priority in the intervention techniques and fire growth graph that was derived from the Building Regulations,
Building by-laws and other building requirements whenever a building is being set up (refer to chapter 3). Eventhough, educational fire safety requirements are within the Building Bulletin 7 (17) or the government authorised documents they do require proper guidelines for fulfilling the fire safety requirements just like any other building. The check list is meant for the school requirements in terms of fire safety which are based according to the law, therefore the evaluators will be able to refer to only a specific document which is directly focused on schools or educational buildings without being involved with the confusion with the requirements of non educational buildings.

7.9.4 Improvement

In order to make an improvement to any existing buildings, a study on the perception of people and professional judgment regarding certain areas needs to be done. Most of the changes and improvements are being done to the extent of having the components and other building provisions such as the services, comfort, ergonomics, surface materials, source of ignition, fuel load and items at risk must be established. The professionals’ clarification and confirmation from the maintenance officers need to be obtained before the trade-off can take place. Activities and functions of the areas under assessment have to be considered. The check list probably will assist in the discovery of the source of ignition, fuel load and disordered systems that cause the fire to ignite and level of severity to be reduced in an area of concerned. The improvement due to the components installed should be maintained 100 % safety performance based on the stages of fire growth where it is expected to contribute. (refer to Diagram 7.4)

The check list has also taken into account the priority of building areas within the categories provided for the educational establishment which was agreed by the Delphi Group1 in chapter 5. It is making the assessment task easier with the detailed coverage of the sub components which contribute towards each head component. The check list is very useful for maintenance and auditing purposes of the fire safety components. It should be used after the points scheme check list contribution by each components has been done by the professionals. The changes in the level of fire safety components performance could resulted some
degree of risk, fire threat, vulnerability or even safety either decrease or increase within the space of a building. So by using the check list, the level of safety standard required can be determined to the level of each of the components. As a result, any improvement or maintenance work that need to be done to the required level of safety, can be achieved.

Another parallel evaluation scheme was also produced along with the component inspection check list. It is very useful to be used as the complete evaluation task for the set of fire safety component within an area or a building. It provides some evaluation points scheme that involve interaction between the fire safety components which do not exist within the inspection check list, particularly to achieve the objectives set for the fire safety policy in the residential school and the educational establishment in general. Both the points scheme and the check list can be combined to produced a mathematical or numerical evaluation scheme for the fire safety evaluation procedure of the educational establishment (refer to Diagram 7.5). The next chapter outlines the formation of the evaluation points scheme for residential schools. This was developed on a similar basis to the development of the procedure for the evaluation of Hospital Patient Areas(2).

This part of evaluation approach can be concluded that a 'Components Appraisal Performance Check List' can only be used effectively once the professional evaluation points scheme check list has been done in the process of evaluation. This part of check list is actually a step ahead of the professional check list using the points scheme which is elaborated in the next chapter.
REFERENCES:


CHAPTER 8: EVALUATION CHECKLIST & PROCEDURE (Group 2)

8.0 Introduction

In this chapter both the Delphi Group 1 and Group 2 are being considered to contribute to the fire safety evaluation points scheme check list. The first Delphi Group 1 is the contribution of members from other fields of expertise representing the local or public views and "non-fire related" and non building professionals whereas the later Delphi Group 2 is totally a contribution given by the fire safety professionals within the fire group members at the University of Edinburgh. Group 1 is formed to assist in the establishment of the framework hierarchical of the fire safety policy for the educational establishment i.e.: the tactics, objectives and policy. Group 2 is generating decisions on the contributory values for the inter-relationships between all elements in the framework which appear to be within the approach of evaluation points scheme.

The purpose of having the fire safety evaluation checklist for school buildings and occupants is to provide guidelines for the evaluator or any other building authorities and surveyors to carry out the task to ensure the establishment is safe from danger of fire at an acceptable level. The evaluation checklist consist of numbers which apply to the fire safety components and other fire safety hierarchies which contribute towards attaining the Fire Safety Policy of the Educational Establishment. The numbers have been generated by a group of fire safety professionals. Once the number has been established, it is available for the evaluator to use it as an assistance in making the assessment or evaluation process and to make decisions for the level of fire safety within a school. The formation of the appraisal check list 2, or worksheet, has been explained in the previous Chapter 7. Here, another evaluation check list which is supposed to be the check list 1, needs to be elaborated. Its existence is important in order to introduce the points scheme appraisal throughout the fire safety evaluation within the educational establishment. Once both of the check list 1 and check list 2 are available, then only the application of the evaluation check lists are used to establish the procedure that every fire safety evaluator needs to follow in order to achieve the standard of fire safety via the set objectives and tactics. By having the number, the whole fire safety evaluation
process can be done with ease by the selected evaluators on each of the safety system and then the synthesis of the fire performance of the school buildings.

8.1 Evaluation Procedure and Some Considerations

In the previous chapter, some of the steps of carrying out the evaluation task using the check list has been explained. The summary of the whole process of evaluation using the Check List 2 can be referred to in Diagram 8.0 and Table 8.0. The evaluation tasks really have to be studied thoroughly to ensure that the check list is being used to its maximum potential in order to get the information needed to enable a decision to be made for the level of safety required in the educational establishment. Diagram 8.0 is to show the ways in which to tackle the educational establishment fire safety problems which have been undertaken through Check List 2 and there is a need for the evaluation points scheme using the Check List 1 which is yet to be covered in this chapter.

The Check List 1 is elaborated in this chapter in order to complete the whole process of evaluation tasks. This Check List 1 is very important as it gives the information needed to proceed with the Check List 2. It will determine the weakness and inadequacy of the fire safety performance level within the areas of buildings, or vice versa, and then only the Check List 2 is to be used to evaluate the fire safety in detail to find out the cause(s) of the decrease in the performance potential.

Therefore, this chapter will cover the policy, objectives and tactics of fire safety for the educational establishment particularly the secondary residential school which is not yet explained. A complete frame work of the evaluation procedure is then introduced and the points scheme of the fire safety evaluation check list 1 for educational establishment by professionals is formed.
PERFORMANCE EVALUATION

COMPONENTS

NORMALLY THE COMPONENTS CHOSEN WILL HAVE TO COMPLY WITH THE FOLLOWINGS:-
1/ Building Regulations
2/ Fire Precaution Act
3/ Fire Authority
4/ Insurance Requirement

ADEQUACY

DEFICIENCY

DECISION MAKING

Assessors need to have knowledge of the probable performance of the various parts of the fire safety system in terms of:-
1/ Severity of the potential threat from fire.
2/ The way various component of fire safety will help to mitigate that risk.

OBJECTIVES

1/Life Safety
2/Property Protection
3/Educational Continuity
4/Environmental
5/Public Anxiety
6/Economic

All the deficiency or efficiency of the system will have to be compared with the objectives.

What is the strategy? and Does it works or performs better/worse? Is it economical and reliable?

Safety <====> Risk

STRATEGY/TACTICS

a) Maintenance
b) Supervision
c) Cost Benefit/effectiveness

a) Up grading
b) Change the whole system/component
c) Trade off
d) Balance the risk and safety factors
e) Check performance
f) Cost Benefit/effectiveness

TECHNIQUES
1/ Creating a Procedure of the Evaluation Processes with check lists.
2/ Provides staff/children with Fire safety knowledge and training programmes
3/ Fire safety management training courses.
4/ Fire safety audit and budget allocation programme. ETC.

Diagram 8.0: Evaluation Procedure Framework
The Evaluation Procedure in this study is normally undertaken in the Pre-Fire Stage of the fire growth graph where serious fire has not occurred anywhere within the buildings and under control. The evaluation processes is very important to carry out at this stage so that precautions steps are established to cater for any unexpected fire occurrence. The following Table 8.0, shows the general possible steps taken to overcome the evaluation of the educational establishment fire safety problems and it's adequacy to the level of acceptable standard.

<table>
<thead>
<tr>
<th>STEP ONE: (WALKING INTO SPACE/AREA)</th>
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<tbody>
<tr>
<td>- SPACE APPRECIATION</td>
</tr>
<tr>
<td>- HOW DOES IT FEEL?</td>
</tr>
<tr>
<td>(LIGHTING/ ACOUSTIC/ ERGONOMIC OR MOBILITY/ SPACIOUS /SIZE AND MOVEMENT / COMFORT/ VENTILATION ETC.)</td>
</tr>
<tr>
<td>- BUILDING DEFECTS OR IMPROVEMENT</td>
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</table>

<table>
<thead>
<tr>
<th>STEP TWO: (EXPERT VISIT)</th>
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</thead>
<tbody>
<tr>
<td>- SET UP QUESTIONNAIRE FOR OFFICIAL / PERSONNEL</td>
</tr>
<tr>
<td>- ASKING ON LOSS IMPACT(CATASTROPHIC/SEVERE/ETC.)</td>
</tr>
<tr>
<td>- VISITING ORGANISED WITH EXPERT</td>
</tr>
<tr>
<td>(ARCHITECT/ BUILDING SERVICES /QUANTITY SURVEYORS /STRUCTURE ETC.)</td>
</tr>
<tr>
<td>- EXCHANGE INFORMATION.</td>
</tr>
<tr>
<td>- PHOTOGRAPHS</td>
</tr>
<tr>
<td>- INTERVIEWS</td>
</tr>
<tr>
<td>(LEVEL OF AWARENESS/TRAINING/MAINTENANCE)</td>
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<table>
<thead>
<tr>
<th>STEP THREE: (SET UP NORMS)</th>
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</thead>
<tbody>
<tr>
<td>- COMPARING WITH THE EXISTING BUILDING REGULATION AND THE FIRE SAFETY PRECAUTIONS ACT 1971 ETC.</td>
</tr>
<tr>
<td>- CURRENT /EXISTING SITUATION WITHIN THE BUILDINGS IN TERMS OF REQUIREMENTS AND INSTALLATION.</td>
</tr>
<tr>
<td>- CHECK LISTS OF THE SAFETY AND RISK FACTORS</td>
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<tr>
<td>- SAFETY AND RISK ASSESSMENT</td>
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<tr>
<th>STEP FOUR: (PROBABILISTIC EVALUATION)</th>
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<tbody>
<tr>
<td>- QUESTIONNAIRES</td>
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<tr>
<td>- INTERVIEWS</td>
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<table>
<thead>
<tr>
<th>STEP FIVE: (DETERMINISTIC EVALUATION)</th>
</tr>
</thead>
<tbody>
<tr>
<td>- SET UP EXPERIMENTAL WORK/TEST</td>
</tr>
<tr>
<td>1/ FIRE SPREAD- Time/Toxicity</td>
</tr>
<tr>
<td>2/ SMOKE MOVEMENT</td>
</tr>
<tr>
<td>3/ ESCAPE/EGRESS TIME.</td>
</tr>
<tr>
<td>- TO CONFIRM THE SYSTEMS OR SUGGESTIONS FOR SOLUTION.</td>
</tr>
</tbody>
</table>
STEP SIX: (PROFESSIONAL JUDGEMENT)

- CONFIRMATION IN TERMS OF DECISION MAKING
- RELIABILITY WITH THE OBJECTIVES SET EARLIER
- GIVING POINTS SCHEME FOR ANALYTICAL APPROACH
- ADEQUACY OR DEFICIENCY

STEP SEVEN: (PERFORMANCE)

- PERFORMANCE TEST ON SYSTEM INSTALLED
  (WATER PRESSURE / FIRE BRIGADE MOBILITY / MATERIAL USED I.E. INTUMESCENT ON OIL PAINT, COLOUR SCHEME etc.)
- ADEQUACY OR DEFICIENCY
- RELIABILITY AND PRACTICALITY
- VALUE FOR MONEY/ COST BENEFIT

Table 8.0: Evaluation Steps

The evaluation procedure is not a straightforward thing that any evaluator can proceed without proper understanding or training. It is even more complex to produce the fire safety check lists and setting up the procedure. However, by referring to the above Table 8.0, the steps that have been undertaken in the study and their corresponding chapters are as follows:-

Step One: Chapter 1, 2, 4, 8
Step Two: Chapter 1, 2, 3, 4, 8
Step Three: Chapter 5, 6, 7, 8
Step Four: Chapter 3
Step Five: Chapter 9
Step Six: Chapter 8
Step Seven: Chapter 7

Basically, apart of the approach taken to produce the evaluation procedure is through an analytical study of the fire safety. Rasbash (1) said that there are three major questions normally asked in the analytical approach; a) What are the objectives of fire safety programme?, b) How safe should the activity be? and c) How safe is the activity? The purpose of using the analytical approach is to find out the loss impact as stated in chapter 4 and benefit of the installed fire safety system, to ensure that the building regulations are being considered in the building design and also to enable the application of new fire safety technology that is available in market. As a result, a fire safety cost benefit can be implemented together with the flexibility in...
design in order to overcome the problems created from danger of fire. Also the fire safety of the building is kept to the acceptable standard.

The loss impact study is related directly and indirectly with the cost of fire. The cost of fire is the significant fraction of the total expenditure and the cost paid for the fire safety protection provision should not exceed the benefit of the extra fire safety that the professional introduced. I.e.: Higher protection should be given to the higher risk areas than any other areas which are less risk and hazard. And with the help of loss impact study amongst the areas, the admin. should be able to allocate the budget for the fire safety system(s) based on the priority of the loss impact expectation given in the case of fire emergency within the areas. This can be done with the knowledge of Trade-off and the product knowledge of the performance expected from each fire safety component systems with the cost to pay for installation and maintenance against the type of danger exist within the areas. Another way is to increase the prevention programs such as training and high level of fire safety awareness to reduce the possibility of any major fire disaster. Or may be a good surveillance camera can be installed to replace a large number of security guards. The balance is normally based on yearly safety allocation and maintenance cost with the selection of appropriate safety systems that provide the acceptable fire safety standard.

Whereas the study of the building regulations has assisted in the understanding of the need in the flexibility in design. The reason is that inflexible regulations can act as a brake to effective design. So, it is important to be able to get at least equivalent safety at perhaps less cost or by less interference with other aspects of design. This is why the study of building performance in chapter 5 and fire safety interaction to achieve the set objectives in this chapter was carried out. Therefore the building regulations including the fire safety objectives should be well understood by the professionals such as the architects, engineers and authorities in designing buildings incorporating fire safety systems.

8.2 Delphi Group 2

With a lot of new fire safety technology introduced into the market, it is important that a quantitative appraisal and analysis to be considered in helping to distinguish the
likelihood of various disaster scenarios. However, the experience and experimental data of actual fires in buildings are not usually available. So a selected panel or a group of professionals is needed to participate in the making of judgement through the Delphi techniques. This has been done by a set of questionnaires for the building occupants and also another questionnaires that were specifically set for the discussion and judgement of the professionals through Group 1 and Group 2. The Delphi groups were complementary and the results are very important as they provide a rational and flexible approach on how to select components of the available technology. Because of that, a method of measuring fire safety levels needs to be developed. Normally, a simple comparison with a norm is usually a "points scheme".

The seven members of Group 2 were involved in fire safety engineering. They are listed in the following table.

<table>
<thead>
<tr>
<th>Numbers</th>
<th>Delphi Group 2 Member</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Dr. D. Dougal Drysdale</td>
<td>Staff</td>
</tr>
<tr>
<td>2.</td>
<td>Dr. Eric W. Marchant</td>
<td>Staff</td>
</tr>
<tr>
<td>3.</td>
<td>Dr. George Grant</td>
<td>Staff</td>
</tr>
<tr>
<td>4.</td>
<td>Dr. Marianne Foley</td>
<td>Staff</td>
</tr>
<tr>
<td>5.</td>
<td>Dr. John Brenton</td>
<td>Staff</td>
</tr>
<tr>
<td>6.</td>
<td>Ms. Barbara Lane</td>
<td>Post-Graduate</td>
</tr>
<tr>
<td>7.</td>
<td>Mr. John Coffey</td>
<td>Post Graduate</td>
</tr>
</tbody>
</table>

A set of questionnaires has been used in the survey and discussions among the professionals to derive the points scheme. Therefore, it was used to develop the framework of the fire safety evaluation procedure. The evaluation check list 1 was developed and this is the core of the whole study. This is explained in the next section.

8.3 The Evaluation Scheme

The fire safety evaluation scheme which was developed for the patient areas within hospitals for the Department of Health and Social Services (June 1982) (4) formed the conceptual basis for the present development. The development and application of the evaluation scheme is now focused on residential secondary schools in Malaysia. The approach of using the contribution values assigned as the points
scheme derived from the Group 2 in this Check list 1 is similar to that produced for the hospital patient areas. However, the development for the residential secondary schools points scheme check list has a major difference in the basic information as it is derived from both the Group 1 and also Group 2. Feed back from the building occupants is being considered. Whereas for the patient areas points scheme check list was directly derived only from the expert opinion or the professionals group selected as the panel members without any direct consideration from the building occupants views.

Group 1 discussion and judgement was combined with the study on the level of awareness of fire safety of the building occupants. This may represent the opinion and views of the people at risk in the schools that we are trying to protect and also from the general public. Basically, the parallel evaluation scheme which was produced along with the Check List 2 is the Evaluation Points Scheme Check List 1. The process of making the Evaluation Points Scheme for educational establishment was undertaken in the following steps:-

a). Establish the "NORM"
b) Establish the fire safety components.
c) Establish the policy, objectives and tactics to achieve.
d) Set up the questionnaire for the Group 2 - fire safety professionals
e) Establish the contribution number or points scheme for each of the fire safety components, tactics, objectives and policy based on their inter-relationships.
f) Set up the Evaluation Check List 1
g) Application of Check List 1.

8.3.1 The Selection of the Norm and fire safety components

Normally the NORM has been set to be the requirements of fire safety given in the building regulations. The importance of the regulations and the fulfilment of the fire safety requirements for buildings in Malaysia has been referred to in several documents and the most common building regulations is the Uniform Building by-laws 1984(2). Therefore, this document was accepted as the Norm for evaluation purposes. From the analysis of the document and the feed back given by the
Group 1 on the lists of fire safety components, fourteen fire safety components were selected for the final list. This list of fire safety components are the safety norm and each needs to be given a number (value) to represent its contribution to the whole total of safety for the area surveyed. Please refer to Chapter 7, section 8.3.3 and Appendix 8.0.

8.3.2 Consistent and Logical Sequence of the Evaluation Process

Complex problems can be arranged in a hierarchy. A typical hierarchy would be in the terminology of Marchant (4). It is being applied to this study by using "Bottom to Top" approach within the hierarchy.

The approach starts from the bottom because of the safety components are the main focal point where the process of evaluation begins. In the earlier chapters of this study, the building regulations, the fire growth, the intervention techniques, the establishing of the risk, safety and hazard which are all related to the safety components and have been thoroughly analysed before other matters were considered. This approach is also used in the process of the formation of the check list and evaluation using the points scheme. The roots of the problems has first been established which are then followed by the components and sub components, tactics, objectives and lastly the fire policy for the educational establishment focused on residential secondary schools.

All the fire safety measures are based on the fire growth graph throughout the approach to tackle the fire problems in schools particularly to maintain the consistency in dealing with the fire problems within the educational establishment. In the further explanation of the following fire safety hierarchical framework is only
elaborated on establishing the policy, objectives and tactics of the fire safety for the Residential Secondary Schools in Malaysia.

8.3.3 The School Fire Safety Hierarchical Framework: Policy, Objectives and Tactics.

The hierarchical framework starts with the fire intervention techniques in buildings. These were selected based on the fire growth graph (Chapter 6 (paragraph 6.6)). The ten fire intervention techniques have helped to define the components and related sub-components of the fire safety for the school buildings. There are fourteen components all together that have been established through the analysis of the building regulations and documents related to fire safety requirements such as the Building by-laws 1984, Law of Malaysia(2) and also agreement by the Group 1 (refer to Appendix 7.0 and 7.3 and Appendix 5.0: Part E of Chapter 5). The analysis procedure was covered in Chapter 3 and the final agreement on the fire safety components is given in Chapter 7. There is not much difference between the techniques intervention and fire safety components as they are inter-related but the latter are more detailed involving sub components which construct the fire safety performance as a whole.

The fire safety components are also used for the trade-off process in the generation of alternative strategies utilising available engineering technologies in the form of partial solutions to particular aspects of the fire safety system conceptualised in Diagram 7.4 of Chapter 7. The aggregation of the collection of partial solutions to provide an equivalent level of fire safety is, however, a non-trivial exercise.
The evaluation procedure framework has been arranged as follows:-

A. Policy
B. Objectives
C. Tactics
D. Intervention Techniques
E. Components
F. Sub-components

<table>
<thead>
<tr>
<th>Policy</th>
</tr>
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<tbody>
<tr>
<td>Fire Safety For Educational Establishment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
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</tbody>
</table>

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
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<table>
<thead>
<tr>
<th>Techniques of Intervention</th>
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<table>
<thead>
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<tbody>
<tr>
<td>1</td>
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<table>
<thead>
<tr>
<th>Sub Components</th>
</tr>
</thead>
</table>

Diagram 8.1: The Fire Safety Hierarchical Framework for Educational Establishment

**Tactics**

A- Limit the severity of fire and smoke spread

B- Provide for successful evacuation of occupants and reduce the rate of casualties and loss of life.

C- Provide for effective fire fighting and rescue operation to reduce the severity of loss and damage.

D- Prevent and control the source of ignition with the prevention and protection measures.

E- Upgrading the level of fire safety awareness, knowledge and practical application of the building occupants.

F- Limit the potential loss with effective maintenance operation, high quality building materials and design.
Techniques of intervention

1. Education and Training
2. Environmental Monitoring
3. Passive Fire Control
4. Fire Detection
5. Communication
6. Egress
7. Fire Fighting
8. Fire Suppression
9. Smoke Management
10. Structural response

Components

1. Building occupants
2. Preparedness for Fire Emergency
3. Fire prevention
4. Internal environment
5. Services
6. Detection
7. Communication and Alarm
8. Evacuation Procedure and Escape Route
9. Fire Fighting
10. Protected areas
11. Auto Suppression
12. Smoke Control
13. Building Structure
14. External Environment

8.3.4 Fire Safety Policy for Educational Establishment in Malaysia

In general, the definition of the four main considerations in order to start the evaluation and assessment of the fire safety for any buildings, particularly in the case of school buildings, are as follows(5):-
I. **Intention** - To protect life safety and property safety. It is exactly to reduce the loss in both areas and to make sure that certain guidelines are followed. Normally, the intention is written in an "Act" produced by or approved by the government.

**INTENTION ===> ACT**

II. **Regulations** - It is the second step that contributes towards the implementation of fire safety requirements. These will have the impact that all developers or individuals should follow what was set down for their own safety. Therefore, the blame or responsibility of any misconduct and failures can be directed to specific personnel. The real function of the regulations is to support the performance statement. The regulations will probably include the "Performance Statement" which should be followed and protected.

III. **Performance** - This will describe the expectation required from the systems used or installed for a particular aspect of safety in terms of fire incidents. It is related to the intention and requirements of the regulations.

IV. **Technical Guidance** - It is a report or a kind of information which providing the specification on how to do the task properly for the given contract or installation works. It is very useful for the designers in order to achieve the expectation out of the performance and as the result of the regulation and intention requirements.

Fire safety policy has been defined as the course or general plan of action adopted by a government, party, organisation or person in order to achieve security against fire and its effects(6). The Fire Safety Policy for Educational Establishment is to provide a fire free environment mainly to save the human lives and to protect the loss of properties within the educational system. It is also trying to build the confidence of the public towards the current government administration and ensuring that the future leader of the country is given the best and safer education to cater the future needs according to the National Educational Policy.

**POLICY ===> FIRE SAFETY FOR THE EDUCATIONAL ESTABLISHMENT**
The major consideration of this policy is to protect the human life and property against fire to maintain continuity in the achievement of the national educational goals for Malaysia. The application of the study will be based on the Secondary Residential (Boarding) School. The main target is to reduce the loss rate of human life and property caused by fire within the educational establishment with several other fire safety objectives by using a fire safety evaluation procedure (scheme). The other objectives are variations on or a combination of these two principles life safety and property protection. The educational buildings should remain safe for the occupants to pursue their task or activities such as teaching, studying or any other learning processes within the premises. The safety boundary can even be extended to the adjoining buildings or surrounding environment which could be affected by the fire in any emergency cases. The occupants, buildings and its content should be able to maintain and develop their performance in a safe environment in order for the educational mission to continue as well as to maintain the undertaking of the students and staff in fulfilling the trust given by the public and parents.

Furthermore, the aim is to provide an adequate evaluation scheme for fire safety requirements for the educational establishment at a flexible and minimal acceptable standard particularly in minimising the cost constraint for fire safety system to be installed and for its maintenance. Thus, the achievable fire safety policy set for the educational establishment will save lives and property within the education estate so that the national educational goals can be achieved. This are stated as follows:-

8.3.4.1 The National Education Goals (15)

1. To Achieve National Unity (community centre) - This can be done by promoting the educational establishment as a place for the community centre not only during emergency but open to some national events. The multi-cultural and multi-ethnic groups can mixed together and perhaps building mutual understanding of each others values without losing the respective respects.

2. To Produce and Provide Quality Manpower Requirements for National Development (knowledgeable and educated) - The development of the country will be better with people of the future generation who are competent and knowledgeable in dealing with national needs. The starting point will probably be
the educational establishment that supposedly provides all the required and proper facilities and services to the pupils at school. In addition, other opportunities for students to specialise in whatever field of studies should be available and supported by the government.

3. To Achieve Democratisation of Education (provide freedom of choice in education). - The people are free to choose the kind of education that they would like to undertake either the sciences or arts streaming background. There are also a number of ethnic and religious schools that are managed by private and government sectors. However, the syllabus and curriculum of the education undertaken should be recognised by the Ministry of Education or international bodies or both in order that the qualifications may allow the people to further their education with a benefit to them and to their country.

4. To inculcate Positive Values. (safety/ responsibilities/ good management/criticality) The education system is aimed to produce a citizenship with good morals and positive values. The pupils will need to be able to think and act positively which involves mental and physical effort. All these positive values within an individual will assist the government to improve and develop the country in a safe environment. Any implementation of system into the public is best to start from the educational curriculum such as building up fire safety environment at work place or the surroundings which then can be diffused into the whole way of life.

Therefore, the objectives of the research are to accommodate the educational establishment with adequate fire safety by achieving the policy which is parallel with the national educational goals.

FIRE SAFETY POLICY FOR THE EDUCATIONAL ESTABLISHMENT ↔ THE NATIONAL GOALS.

It is important to understand that in achieving the national goals, the safety factors should be the initial steps in determining the continuity of the whole education process so that there is no interruption. The problems which are already acknowledged within the educational establishment can be listed as follows:-

1. Fire accident has been recorded within the Educational Establishment and it was found to be affecting the process of education either for the individual or the whole organisation. The fire accidents have caused
some moral and political issues especially those which involve the trust of the public to the competence and credibility of government.

2. There is a need to have a set of evaluation schemes for educational buildings in order to judge or examine the building safety standards and also to see whether the existing buildings or new buildings are at an acceptable standard or not.

3. Standardisation is needed for educational buildings for a better management and control of the educational development.

In order to tackle the above existing problems and also to cater the future expectation within the educational establishment in terms of fire safety, several objectives, tactics and intervention techniques has been introduced which will assist us to ensure reaching the overall fire safety policy. Therefore, the objectives of the study are to accommodate the educational establishment with fire safety requirements at the minimum acceptable level to the eyes of the occupants, public and the government as a whole. Hence contributing towards achieving the Fire Safety Policy of the Educational Establishment and the National Education Goals.

### 8.3.5 Fire Safety Objectives for the Educational Establishment

The definition of an objective is the specific goal to be achieved. The goal is normally related directly to the Policy set by the body, person or organisation. In this case, the goal is the Fire Safety Policy set for the Educational Establishment which refer specifically to the (Government) Residential Secondary School and several objectives that has been identified and based on the agreed sequence of priority from the Delphi Group 1 are: - (Refer to Appendix 8.1, question 8)

A. Life Safety (LS)
B. Educational Environment (EE)
C. Property Protection (PP)
D. Continuity of the Educational Mission (EC)
E. Public Anxiety (PA)
F. Economy (ECO)
8.3.5.1 Life Safety (LS)

The lives of the building occupants of the specify premises within the educational establishment i.e.: schools, universities and other administration buildings need to be safe. The children and staff at school are the main reason for the existence of a school. Therefore their lives should be the priority in almost every cases involving educational buildings. However, this particular study will focus more on residential secondary schools in Malaysia. Why it has to be the residential secondary school? The reasons are as follow:-

i) Students age (12 → 18 years old) are big enough to cater and responsible to themselves while staying away from their own family circle.

ii) There are various types of secondary schools either private or government administration. These school buildings should be standardised in safety requirements so that a model school can be used as a reference. This could be the best government schools.

iii) Students will be staying within the school compound for 24 hours a day.

iv) The government policy on education should be the model for others to set their target and base their aims. Therefore, a proper document can be produced by the government for a standard evaluation procedures.

Life safety could involve the students, teachers, staff and any visitors within the premises. The loss of life is a major issue to every individual, the public even at the national and international levels. Therefore, the school administration will have to be responsible to answer the problems that exist with fire safety at school and these also include the responsibility of the Ministry of Education.

Assessment of life safety is the process of estimating the quality of security against fire and its effects. There is a need to understand the fundamentals of the life safety concept because there is no formula which identifies or guarantees a building that is safe from fire. However, a checklist may help to ensure consideration of parameters which create risk and those which tend to offset or mitigate a portion of that risk(3).
A concern for life safety implies avoiding exposure to harmful levels of products of combustion. This goal is usually effected by the likelihood of fire initiation and/or separating endangered individuals from the harmful effects of fire. Generally there are six considerations that need to be understood in the assessment of life safety from fire in buildings(7).

a) Life safety factors
   (Time, The Critical Level, Available Fuel Variations)

b) Susceptibility of Occupants to Fire
   (Age, Mobility, Awareness, Knowledge, Density and Control of Occupants)

c) The Nature of Fire in Buildings
   (Ignition Potential, Fire Growth, Spread of Smoke and Fire)

d) Safety Strategies
   (Fire Prevention, Fire Management, Occupant Management)

e) The Literature on Emergency Egress
   (Exit facility and Carrying Capacity, Egress Sign and Emergency Lighting, Occupant Response to Fire)

f) Assessment Tools: Evaluating the risk.

8.3.5.2 Education Continuity (EC)

This second objective is a combination between the property protection and life safety objectives because both are major contributors towards the operation of the school. They are important for educational continuity, providing a good educational environment with sound economy and perhaps for public anxiety. All of these contribute towards the overall objectives of an educational establishment. Each one of the areas within the educational establishment may be unique. Some areas are for teaching purposes but some are for practical training, reading, writing, discussion or both. Even these functions can be overlapping in terms of the suitability of spaces. On the other hand, for education continuity, the functions of a space should be able to be maintained without any interruption in order to achieve certain educational goal(s). For example, a classroom is a place where teaching is done and a laboratory is a place for experimental work. The function of a laboratory is unique but that of a classroom is not unique. Therefore, if a laboratory is affected by
an emergency, the whole process of experimental work is interrupted or cancelled. Whereas if a classroom is in an emergency condition, it is most likely that the teaching can still be carried out in a laboratory or elsewhere, as most spaces may suit the purpose and requirements for teaching. This shows that it is important for the building areas to be considered in terms of fire safety for each particular space in the school building.

8.3.5.3 Property Protection (PP)

Another common main objective of fire safety is the protection of property for the sake of economy or data, based on its importance. In this case, the school buildings, hostels and any other buildings within the premises plus their contents. Property can be a personal or a public concern. Even though most property is associated with its cost but another major factor to be considered is the loss impact of certain things i.e.: the time, commitment and effort to collect or accumulate the items within the school areas which are hardly to be valued in terms of money. For example, the collection of information and research works throughout the years which are kept within the resource centre, if they were involved with fire and were burnt and destroyed, the loss impact of that particular property is not as high to the whole educational establishment within the district but may be extremely high for the school records of achievement and to the staff that has been working on it throughout the years.

It is the same for the hostel or other school buildings where if they were burnt in fire, the occupants will not be able to continue the particular activities and may lose shelter for a significant period of time before they can resumed as normal. So the occupants will lose their valuable time (particularly for those who having major examination) and may affects the continuity of the whole educational mission if fire do destroyed the property. It has been agreed by the occupants of the selected schools and also by the members of the Delphi Group 1 in Part E (refer to Appendix 8.1), that property protection should considered as a very important objective of fire safety.
In order to achieve the educational environmental objective, the school building should be adequately installed with the appropriate safety measures against fire and also isolated from any distraction such as unwanted fire, bad odour, smoke, noise and views. Some control factors must be considered for instance, the school building should be constructed with a proper fire resisting materials, located away from major traffic, sewage treatment plants or anything which are unpleasant. Bad views, odour and discomfort could be caused by the nearby activities such as palm oil processing factory, a pig farm (poultry), drainage system or road systems. Therefore, the location of the school building must be well planned by the local authority and professionals before it is approved for construction. Sign systems, regulations and supervisors should always remind the pupils about their safety during all activities. The pupils should also be exposed to certain fire safety training and provided with adequate knowledge on fire. A positive attitude towards facing the fire emergency will need to be established among the pupils in order to achieve the best outcome. However, the administrative officer will also have to attend fire management courses or programmes so that the pupil will be benefited by them as well. So the environmental objectives really need to be appraised internal and external factors of the building to achieve the target of the fire safety policy. If there is a fire or any other natural disaster such as flood within the community, how would it affects the education operation of that school, i.e. the water and electricity supply, educational areas for the continuity of education and yet at the same time the school provides refuge to the community? How would it affect the student's education if some of the buildings such as the assembly hall and fields are being used by community for sports or other events? Are the pupils really safe from the harm of fire and deliberate action of arsonist? Are they secure?

generally the objective is to ensure that the government is providing adequate safety measures i.e. fire safety requirements into the educational systems. The public are really concerned about the safety of the students while remaining in the school compound. It is important that the public are convinced about the safety level
provided by the government for the pupils are adequate. Normally education is run by the government and some private organisation that are responsible to maintain the school’s mission. Therefore, in gaining the trust and for the moral, political and education values, the safety of the school should be the priority. The reason behind this is that any fire disasters within the school compound will definitely affect the credibility of the current Government which is lead by a particular political party. The students need to be well educated and protected against fire with a good training skills and adequate fire safety knowledge in order to remind other about the danger of fire. Therefore an evaluation scheme for fire safety in school is important to assist the Government in ensuring that the schools are well protected and fire problems within the establishment are being identified and reduced continually.

8.3.5.6 Economy (Eco)

Another part which is considered to be very important in terms of economy is recovery management. The purpose of having a recovery management are as follows:-

i. To ease the decision making by the authority (Ministry of Education)
   - Which building should be considered for the continuity of the mission in terms of it’s priority, function and contribution?

ii. To suggest the best choice to replace the loss.

iii. To ensure that the mission continuity especially the elements of the Education Policy are sustained.

iv. To limit the time loss in management.

v. To revise the cost benefit appraisal.

These objectives are among the most important targets to be achieved by the studies and the end result will produce a safe building and environment for the whole educational building. Besides, prevention of conflagration and reduction of damage and loss in terms of human lives and properties, both major objectives are very much interrelated with the reduction in cost for the same effectiveness of the safety systems and installation and also recovery purposes. In order to achieve each and every single objective, a serious and critical study on the Fire Safety Requirements need to be carried out by producing an assessment list of Fire Safety Requirements
for buildings against fire. This study is involved particularly with the Residential Secondary School Buildings.

Through prevention of conflagration and reduction of damage, life safety and property losses will be secured by introducing a proper fire safety installation. Hopefully the educational establishment fire safety evaluation procedure to be introduced will assist in achieving the minimum requirement of installation and minimum budget spending. Therefore, the chance of a vital accident cause by fire and the cost of recovery in case of fire can also be reduced. However, the building itself will need to be protected by some of the passive and active systems that are available. These actions will resulting a non serious fire hazard and an easy recovery for the continuation of mission. It also help to limit the impact of environmental pollution to the surrounding areas and globally. Hence, it builds more confidence in the public about the importance of having fire safety requirements fulfilled.

The rank order agreed by the Delphi Group 1 to the above objectives are given in Chapter 5: paragraph 5.7, Part E.

8.3.6 Tactics to Achieve Fire Safety in Educational Establishment

Once the importance of the fire safety policy and objectives has been elaborated, it is best to be able to establish the relevant tactics that will contributes towards achieving the objectives. There were several attempts to produce the final list of tactics which are considered to cover the achievement of all the objectives. The last three steps in obtaining the final list of tactics is shown in Table 8.1:-
<table>
<thead>
<tr>
<th>1st Step</th>
<th>Objectives</th>
<th>2nd Step</th>
<th>Final Step</th>
</tr>
</thead>
<tbody>
<tr>
<td>Provide for successful evacuation of occupants</td>
<td>A, C, D</td>
<td>Provide for successful evacuation of occupants</td>
<td>Reduce the rate of casualties and loss of life</td>
</tr>
<tr>
<td>Provide for effective fire fighting and rescue operation</td>
<td>A, B, C, D, E, F</td>
<td>Provide for effective fire fighting and rescue operation</td>
<td>Reduce the severity of loss and damage</td>
</tr>
<tr>
<td>Limit the spread of fire and smoke</td>
<td>A, B, C, D, E, F</td>
<td>Limit the spread of fire and smoke</td>
<td>Limit the severity of fire and smoke spread</td>
</tr>
<tr>
<td>Limit the severity of fire</td>
<td>A, B, C,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control source of ignition</td>
<td>A, B, C, D, E</td>
<td>Prevent and control source of ignition</td>
<td>Increase Fire Prevention and protection measures</td>
</tr>
<tr>
<td>Prevent the ignition of fire</td>
<td>A, B,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Limit the potential loss</td>
<td>A, B, F</td>
<td>Limit potential loss with effective maintenance operation, high quality of building materials and design</td>
<td>Limit potential loss with effective maintenance operation, high quality of building materials and design</td>
</tr>
<tr>
<td>Provide for effective maintenance</td>
<td>A, B, C, D, E, F</td>
<td>Increase the quality of building materials and design.</td>
<td>Increase the level of fire safety awareness</td>
</tr>
<tr>
<td>Increase the quality of building materials and design.</td>
<td>D, E, F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increase the level of fire safety awareness</td>
<td>A, B, C, D, E, F</td>
<td>Increase the level of fire safety awareness</td>
<td>Increase the level of fire safety awareness</td>
</tr>
</tbody>
</table>

where: A: Life safety B. Property Protection C. Education Continuity D. Education Environment E. Public Anxiety F. Economy

Table 8.1: Development of the Tactics

Therefore, 6 final major tactics was formed to represent the overall objectives that need to be done in order to achieve the total policy of fire safety for the educational establishment. Further sub-tactics were formed during the development of the list and can be referred to in the Appendix 8.2. The interactions and connections between the components, tactics and objectives in the hierarchical framework are shown in the coloured tables 8.21, 8.22 and 8.23 in Appendix 8.3, where a successful relationship of these fundamental fire safety tactics may be achieved with more than one combination of safety components. Those tables are very useful as they help the professionals to make decisions on acceptability and equivalency.
Using a points scheme is basically to form the base for further judgement on the adequacy of fire safety components or the level of safety against the level of risk or hazard of fire that is available within the system in a particular area. The areas then can be summarised in terms of their acceptable or not acceptable level of fire safety based on the total number of points scored compared to the stated benchmark. The benchmark then leads the evaluator to make a decision on the adequacy of fire safety for that areas involved or even the whole building as a total evaluation. The Fire Safety Evaluation Using Points Scheme has a number of benefits, among them are:

1. To be able to evaluate an area for its fire safety adequacy with respect to the level of acceptability.
2. Areas of building being evaluated will lead to the evaluation of the whole building in terms of overall fire safety requirement or performance.
3. Buildings within the systems or premises that has been evaluated for its fire safety requirement will give an overall assessment of the whole school buildings against possible danger of fire in total.
4. Using the points scheme can convince the non-technical professionals and authorities on the importance of considering fire safety. They are mainly involved with decision making, and should know the seriousness of the need to comply with the fire safety requirements.
5. Comparison between schools within the educational establishment can help the Ministry of Education or any authority to make decisions on the current and future development of the establishment particularly in creating a safer environment with all the essential safety provisions. This involves the allocation of budget, facilities, building design, level of supervision and provision needed. Also involved the maintenance of the buildings and activities of the education curriculum. This would enable the available money to be spent to the best advantage.
6. The most important aspects of the study is that, the education administrators will be able to help in achieving the Fire Safety Policy for The Educational Establishment by using the Fire Evaluation Procedure provided along with the National Educational Policy.
Even though, the numbers for the points scheme has been generated by UK professionals, the numbers can still be used by the local evaluators in Malaysia as guidelines. However, in order to enable to apply the number in the Malaysia scenario, another set of numbers will have to be established based on the existing numbers with the participation of the local professionals. In other words, in order to implement it in Malaysia context, another set of contribution numbers may be needed to be generated by the Malaysian professionals or local authorities as a Delphi Group. This procedure would become necessary if the given numbers are not convincing or reliable to the local authorities in Malaysia.

8.4.1 The Target Populations or Occupancy

Diagram 8.2: The Fire Safety Evaluation Points Scheme for Secondary School
Note: MRSM is a Science School Sponsored by Public Trust Fund and Government.

Diagram 8.3: The Target Population (Occupancy) Within the Educational Establishment

The common areas for the above occupants within the educational establishment are referred to the Delphi discussions in Chapter 5 where the priority is given to supervise particular group of occupant based on their common usage of certain areas. The related table can be referred to paragraph 5.7.2.:Q:2.

8.4.2 The Division of the Building Types and Areas (Delphi Part C)

The building types are divided into 5 categories:-

I. Building Type A: Academic Building (I) (Theoretical Development)

II. Building Type B: Academic Buildings(II) (Mental and Skills Development i.e.: Laboratories and Workshops )
III. Building Type C: Accommodation and Hostel Buildings
   (Health, Rest and Food)
IV. Building Type D: Administrative and Managerial Buildings
V. Building Type E: Other Buildings (Spiritual, Physical, Psychological and Business)

Most of the building areas being considered in the survey checklist are enclosed areas with proper walls, ceilings and floors. This part has also been covered previously in chapters 5 and 7, where the areas priority are given so that evaluation tasks are arranged based on their importance.

8.4.3 Inter-relations Among the Hierarchy Framework

There are two steps to be taken to obtain the inter-relationships between the different level of the hierarchical framework for the fire safety of the educational establishment.

i. First, is to see the inter-dependent relationships among the components, tactics, objectives and policy via visual bubble-diagrams or tables as the initial steps and

ii. Secondly, to ask questions for relationship contribution points from the experts by using a set of questionnaires for which the design is based on the policy, objectives, tactics and components inter-relationships. The output of the questionnaires is expected to give the required inter-relations points among the levels of the hierarchical framework which can be used in the evaluation of the acceptable level of fire safety for an area or even to evaluate the total building.

8.4.3.1 Visual Bubble Diagrams and Tables: Inter-relation study

An example of the inter-relationship between Components vs. Components.
The contributions given by the visual bubble diagrams and tables are not very clear to the extent of trying to evaluate an area in terms of fire safety in a more consistent results. A lot more of the bubble diagrams are presented in the Appendix 8.3. There is a need for better approach to confirm the relationships and interactions between the different levels of hierarchical framework so that each of the fire safety components being assessed will have a certain value that is given as the agreed contribution points for the whole fire safety evaluation. This part is introduced by the second approach using numbers as the contribution points and this has lead to a more confident and consistent results from the evaluation task.

8.4.3.2 The Framework Interaction Points Schemes - Questionnaire

There are 4 steps or level of sets of questionnaires, as shown in the following interaction, Diagram 8.4.

```
Policy level  ---> Step One
       v
Objectives level  ---> Step Two
       v
Practice level  ---> Step Three
       v
Component level  ---> Step Four
```

Diagram 8.4 : Hierarchical Framework Interaction Stages

The questionnaires were designed into 3 parts:-

a. The explanatory notes on the purpose and objectives of the questions in each division. This is to guide the experts or respondents of the questionnaire regarding the limitation that should not be exceeded.

b. The interaction boxes and arrows between the levels of the hierarchical framework.

c. The contribution number between 0 to 10 is to be given or written in each of the boxes provided. Each of the number is explained to what extent they are
contributing and a range of limitation is represented by those contribution numbers. Only one number should be given for each interaction.

The feedback from the questionnaires was analysed to arrive at the average number for each of the interactions covered in the study. Examples of the whole questionnaires is given in the Appendix 8.4. An example is given as follows:-

**POINT SCHEME FOR FIRE SAFETY OF THE EDUCATIONAL ESTABLISHMENT**

The following are questions set to look at the relationship and contribution from each of the fire safety hierarchies (objectives, tactics, components and sub components) of the Educational Establishment. In this study case, the fire safety requirement for a fully residential secondary school in Malaysia is being focused.

Each of the hierarchies contributes toward some preparation of the overall achievement of the educational fire safety policy. The contribution is rated numerically by the member of Fire Group within this department. Analysis of these data is to arrive at a scale of evaluation value for the educational establishment.

**STEP 1: Objectives Vs Policy**

In any fire emergency, the rank order of importance with regards of the fire safety relationship must always relate to the **Fully Residential Secondary School**. Its main contribution is towards achieving the fire safety policy of the educational establishment. Each relationship is having a total mark of 10. Therefore, based on your perception, please give a number among 0 - 10 for each of the following relationships and state the contribution points in achieving the particular hierarchy between the objectives and policy.

0 = not relevant.
1, 2 = minor relation, insignificant contribution
3, 4 = minor relation, significant contribution
5, 6 = moderate relation, significant contribution
7, 8, 9 = major relation and major contribution
10 = direct relation with highest contribution.

The Policy to be achieved is mainly the Fire Safety of the Fully Residential Secondary School in Malaysia. Try to assess the relationship independently in a relative rating scale. Write the number or points in each of the boxes for the objective.
STEP 2: Tactics Vs Objectives

A similar procedure is applies to this following relationships between tactics and objectives of the evaluation point scheme. The tactics are having the same total mark of 10 for each relationship. Base on your own perception and judgement, place a number representing the contribution from each of the tactics, in order to achieve the objectives of the fire safety for secondary school in Malaysia.

2 nd. hierarchy

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>TACTICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIFE SAFETY</td>
<td>Limit the severity of fire and smoke spread.</td>
</tr>
<tr>
<td></td>
<td>Provide for successful evacuation of occupants and reduce the rate of casualties.</td>
</tr>
<tr>
<td></td>
<td>Provide for effective fire fighting and rescue operation to reduce the severity of loss and damage.</td>
</tr>
<tr>
<td></td>
<td>Prevent and control the potential source of ignition with the fire prevention and protection measures.</td>
</tr>
<tr>
<td></td>
<td>Up grade the level of fire safety awareness, and practical knowledge.</td>
</tr>
<tr>
<td></td>
<td>Limit the potential loss with effective maintenance operation, high quality building materials and design.</td>
</tr>
</tbody>
</table>

PLEASE WRITE THE NUMBER OR POINT IN THE BOX BETWEEN

Minimum 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 OR 10 Maximum

DEPENDING ON YOUR OWN PERCEPTION ABOUT THE CONTRIBUTION BY EACH OF THE TACTIC AND THE RELATED ARROW TOWARDS THE PARTICULAR OBJECTIVE ONLY, WHERE THE TOTAL OF 10 IS GIVEN FOR EACH RELATIONSHIP.
Step 3: Components Vs Tactics

In order to ensure that the targeted tactics mentioned earlier will be able to achieve, several fire safety components have been selected for the educational establishment particularly for the fully residential secondary school. There are 14 fire safety components which derived from the Delphi Group discussion and also from the patient areas in the hospital fire safety evaluation scheme (by E.W. Marchant).

### 3rd hierarchy

<table>
<thead>
<tr>
<th>POINT COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING OCCUPANTS</td>
</tr>
<tr>
<td>PREPARED FOR FIRE EMERGENCY</td>
</tr>
<tr>
<td>FIRE PREVENTION</td>
</tr>
<tr>
<td>INTERNAL ENVIRONMENT</td>
</tr>
<tr>
<td>SERVICES</td>
</tr>
<tr>
<td>DETECTION</td>
</tr>
<tr>
<td>COMMUNICATION AND ALARM</td>
</tr>
<tr>
<td>EGRESS OR ESCAPE</td>
</tr>
<tr>
<td>FIRE FIGHTING</td>
</tr>
<tr>
<td>PROTECTED AREAS</td>
</tr>
<tr>
<td>AUTO SUPPRESSION</td>
</tr>
<tr>
<td>SMOKE MOVEMENT</td>
</tr>
<tr>
<td>BUILDING STRUCTURE</td>
</tr>
<tr>
<td>EXTERNAL ENVIRONMENT</td>
</tr>
</tbody>
</table>

### 4th hierarchy

- **TACTICS**
  - (A) LIMIT THE SEVERITY OF FIRE AND SMOKE SPREAD

PLEASE WRITE THE NUMBER OR POINT IN THE BOX BETWEEN 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 OR 10 DEPENDING ON YOUR OWN PERCEPTION ABOUT THE CONTRIBUTION BY EACH OF THE COMPONENT AND THE RELATED ARROW TOWARDS THE PARTICULAR TACTIC ONLY, WHERE THE TOTAL OF 10 IS GIVEN FOR EACH RELATIONSHIP.

Therefore, please give a number between 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 to 10 to each of the following relationship base on your perception on which of them contributes the most points in achieving the particular hierarchy.

- **0** = not relevant.
- **1, 2** = minor relation, insignificant contribution
- **3, 4** = minor relation, significant contribution
- **5, 6** = moderate relation, significant contribution
- **7, 8, 9** = major relation and major contribution
- **10** = direct relation with highest contribution.
Step 4: Components Vs Components

There are 14 x 14 relationships between the fire safety components for the educational establishment. Each of the component do have indirect and direct relationship between them. Now, please consider and look closely the relationship between the components and with your own perception and judgement, please give each of the relationship a point of contribution towards that particular component. The point scheme is still the same as the previous steps mentioned earlier.

<table>
<thead>
<tr>
<th>COMPONENT</th>
<th>POINT</th>
<th>COMPONENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUILDING OCCUPANTS</td>
<td></td>
<td>BUILDING OCCUPANTS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PREPARED FOR FIRE EMERGENCY</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FIRE PREVENTION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>INTERNAL ENVIRONMENT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SERVICES</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DETECTION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>COMMUNICATION AND ALARM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EGRESS OR ESCAPE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>FIRE FIGHTING</td>
</tr>
<tr>
<td></td>
<td></td>
<td>PROTECTED AREAS</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AUTO SUPPRESSION</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SMOKE MOVEMENT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BUILDING STRUCTURE</td>
</tr>
<tr>
<td></td>
<td></td>
<td>EXTERNAL ENVIRONMENT</td>
</tr>
</tbody>
</table>

Please write the number or point between

Minimum 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 OR 10  Maximum

Depending on your own perception about the contribution by each of the box and the related arrow towards the particular component only, where the total of 10 is given for each relationship.

Therefore, please give a number between 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 to 10 to each of the following relationship base on your perception on which of them contributes the most points in achieving the particular hierarchy.

0 = not relevant.
1, 2 = minor relation, insignificant contribution
3, 4 = minor relation, significant contribution
5, 6 = moderate relation, significant contribution
7, 8, 9 = major relation and major contribution
10 = direct relation with highest contribution.
The questionnaire was designed as above with the objectives of obtaining the interaction contribution points between the hierarchical framework. Although a broad knowledge of fire safety in buildings is required that would enable one person to formulate the question and to understand the relevance of the answer, but the types of questions indicate that none is likely to be answered expertly by one person. So a group of people is needed to contribute to the end result which then the average scores of each of the relevant interaction are made to be the confident result with less ambiguous. The group is called Delphi Group 2. The problems of ambiguity can be eliminated by formulating the questions in a simple form and that its' content is within the direct expertise of at least one member of the selected panel as suggested by Marchant (8).

8.5 Standardisation of the Points Scheme by Selected Panels

Marchant(8) said that it may be accepted generally that fire safety engineering is too complex for the opinion of a single expert to be valid and therefore, a group of "ordinary" experts may be the appropriate panel. The choice of having the group member from the Fire Group is that they represented the panel or respondents who are having a similar knowledge base with a simple consensus of opinion. This is important for consideration in order to reduce the heterogeneous nature of the panel of respondents where each question or questionnaire will be answered with a different degree of validity and a different degree of confidence on the anonymous responses to rigorous statistical analysis. Marchant(8) also stated that the intelligent and the integrity of the individual has to be trusted so that the individual responses to questions and the numerical ranking of choices can continue to be regarded as independent but accepted as reasonably reliable with respect to the selected goal/s. Some of the techniques to reduce the bias and creating a common knowledge of the subject among the panel members are shown in the next paragraph.
A common knowledge base was developed by using a set of questions that discussed the level of contributions to fire safety. Sets of questions were presented to the Delphi Group 2 through several meetings. The format for the meetings was:-

i. Approach the professional individually and inform the purpose of the study briefly.

ii. Set the date, time and venue for the meeting
   a) Introduction and purpose of study.
   b) Formation of the Delphi Group 2
   c) Questionnaire and the target outcome

iii. Distribution and Collection of the Questionnaire
   a) Each member is given a set of questionnaires in a file and ways to approach the questions is discussed without influence the answers.
   b) The importance of the restriction and limitation is conveyed regarding the questions.
   c) Any doubt and difficulties to understand the questions is discussed within the meeting or through electronic mail system within the department.
   d) Set the date to be returned.

The benefit of using the above approach in conducting the meeting, few problems in Delphi Techniques can be solved such as to eliminate ambiguity in the questions asked of each respondent. A common knowledge is maintained through the meeting and the explanation given by the researcher as part of subprocess of group education to achieve a degree of common understanding of the strategic purpose and the tactical operation of the overall task becomes valid as suggested by Marchant(8).

8.6 Questionnaires Analysis

The analysis of the feed back given by the professionals or the Delphi Group 2 through the questionnaires are being analysed using the excel package. All the given points of the frame work interaction between the levels of hierarchy is
summarised into average points. This average points are representing the level of interaction between the different level of hierarchical framework where the higher hierarchy can be achieved only to the extend of one step higher, not more than that. It means that the components of a fire safety level are only contributing towards achieving the several tactics level that are listed and not yet to the next higher level of the hierarchical framework which is the objectives level. The same goes to all the interactions using the questionnaires. The values given by the Group 2 is between 0 to 10 but yet it can be treated as 0 to 5, based on the description given for the grouping of the numbers for each of the relationships.

Groups of number, range 0-->10  Likert type scale:[0,5]

<table>
<thead>
<tr>
<th>Groups of number</th>
<th>Likert type scale</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>=&gt; 0</td>
<td>not relevant.</td>
</tr>
<tr>
<td>1, 2</td>
<td>=&gt; 1</td>
<td>minor relation, insignificant contribution</td>
</tr>
<tr>
<td>3, 4</td>
<td>=&gt; 2</td>
<td>minor relation, significant contribution</td>
</tr>
<tr>
<td>5, 6</td>
<td>=&gt; 3</td>
<td>moderate relation, significant contribution</td>
</tr>
<tr>
<td>7, 8, 9</td>
<td>=&gt; 4</td>
<td>major relation and major contribution</td>
</tr>
<tr>
<td>10</td>
<td>=&gt; 5</td>
<td>direct relation with highest contribution</td>
</tr>
</tbody>
</table>

With this in mind, the Likert type scale which is [0,5] as suggested by F.J.Dodd and H.A.Donegan (9) can be used as a scale to estimate or measure the individual opinion.

8.6.1 Objective Vs Policy (Step 1)

The results of objectives to policy vector obtained from the analysis of the questionnaires for the given values by the Group 2 is shown in Table 8.3. The Objectives are mainly to achieve the Fire Safety Policy of the Residential Secondary School in Malaysia. The life safety still remains as the priority objectives in achieving the total fire safety policy for the educational establishment.

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>Average</th>
<th>Percentages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Life Safety</td>
<td>9.6</td>
<td>25%</td>
</tr>
<tr>
<td>Property Protection</td>
<td>7.0</td>
<td>18%</td>
</tr>
<tr>
<td>Education Continuity</td>
<td>6.9</td>
<td>18%</td>
</tr>
<tr>
<td>Education Environment</td>
<td>5.3</td>
<td>14%</td>
</tr>
<tr>
<td>Public Anxiety</td>
<td>5.0</td>
<td>13%</td>
</tr>
<tr>
<td>Economy</td>
<td>5.3</td>
<td>14%</td>
</tr>
</tbody>
</table>

Table 8.3: Objectives To Policy Vector
8.6.2 Tactics Vs Objectives (Step 2)

Table 8.4, tactics to objectives vector shows that the life safety objective can be achieved almost 100% by considering all the tactics in sequence based on its percentages contribution. Firstly, the management should provide adequate evacuation provision for occupants in order to reduce the rate of casualties. Secondly, they should limit the severity of fire and smoke spread by replacing items with more non-combustible materials and proper fire resistance for building structures. Then the third tactic is upgrading the level of fire safety awareness and practical knowledge followed by prevent and control the potential source of ignition with the fire prevention and protection measures. The last two tactics are only contributing extra safety provision to the whole system as the first four have already covered more than 50%. The percentages contribution values seems to be very significant for each of the objective based on the first three highest given scores or percentages.

Similarly, other objectives can also be achieved by referring to the guidelines and interaction given in the Table 8.5 which was produced through the expert opinion.

8.6.3 Components To Tactics Interaction (Step 3)

The priority interaction between the components and the tactics is given in Table 8.5. The components which are related very closely to the successful implementation of the tactics are shown in the table. For example, the tactic for upgrading the level of fire safety awareness and practical knowledge among the occupants needs to have the following components but only considered the points that have an average percentage (%) score is 5 and above:-

- a. Prepared for fire emergency f. Egress or escape
- b. Building occupants g. Protected areas
- c. Fire prevention h. Fire fighting
- d. Communication and alarm i. Detection
- e. Internal environment
Table 8.4: Tactics To Objectives Vector

<table>
<thead>
<tr>
<th>TACTICS</th>
<th>OBJECTIVES</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>1. Limit the severity of fire and smoke spread.</td>
<td>9.0 18.1%</td>
</tr>
<tr>
<td>2. Provide for successful evacuation of occupants and reduce the rate of casualties.</td>
<td>9.6 19.3%</td>
</tr>
<tr>
<td>3. Provide for effective fire fighting and rescue operation to reduce the severity of loss and damage.</td>
<td>7.4 14.9%</td>
</tr>
<tr>
<td>4. Prevent and control the potential source of ignition with the fire prevention and protection measures.</td>
<td>8.4 16.9%</td>
</tr>
<tr>
<td>5. Upgrading the level of fire safety awareness and practical knowledge.</td>
<td>8.7 17.5%</td>
</tr>
<tr>
<td>6. Limit the potential loss with effective maintenance operation, high quality building materials and design.</td>
<td>6.6 13.3%</td>
</tr>
</tbody>
</table>

Note:
A = LIFE SAFETY
B = PROPERTY PROTECTION
C = EDUCATION CONTINUITY
D = EDUCATION ENVIRONMENT
E = PUBLIC ANXIETY
F = ECONOMY
Table 8.5: Components To Tactics Interaction

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>TACTICS (Average)</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>C</td>
<td>D</td>
<td>E</td>
<td>F</td>
</tr>
<tr>
<td>BUILDING OCCUPANTS</td>
<td>5.9</td>
<td>6.4%</td>
<td>8.3</td>
<td>8.0%</td>
<td>6.1</td>
<td>6.2%</td>
</tr>
<tr>
<td>PREPARED FOR FIRE EMERGENCY</td>
<td>6.9</td>
<td>7.5%</td>
<td>8.7</td>
<td>8.4%</td>
<td>8.1</td>
<td>8.2%</td>
</tr>
<tr>
<td>FIRE PREVENTION</td>
<td>7.7</td>
<td>8.4%</td>
<td>6.9</td>
<td>6.6%</td>
<td>5.7</td>
<td>5.8%</td>
</tr>
<tr>
<td>INTERNAL ENVIRONMENT</td>
<td>7.1</td>
<td>7.8%</td>
<td>7.6</td>
<td>7.3%</td>
<td>5.1</td>
<td>5.2%</td>
</tr>
<tr>
<td>SERVICES</td>
<td>5.3</td>
<td>5.8%</td>
<td>5.3</td>
<td>5.1%</td>
<td>6.4</td>
<td>6.5%</td>
</tr>
<tr>
<td>DETECTION</td>
<td>8.3</td>
<td>9.1%</td>
<td>9.1</td>
<td>8.8%</td>
<td>7.7</td>
<td>7.8%</td>
</tr>
<tr>
<td>COMMUNICATION AND ALARM</td>
<td>7.3</td>
<td>8.0%</td>
<td>9.3</td>
<td>9.0%</td>
<td>8.4</td>
<td>8.5%</td>
</tr>
<tr>
<td>EGRESS OR ESCAPE</td>
<td>2.1</td>
<td>2.3%</td>
<td>9.6</td>
<td>9.2%</td>
<td>7.1</td>
<td>7.2%</td>
</tr>
<tr>
<td>FIRE FIGHTING</td>
<td>7.9</td>
<td>8.6%</td>
<td>5.3</td>
<td>5.1%</td>
<td>9.7</td>
<td>9.8%</td>
</tr>
<tr>
<td>PROTECTED AREAS</td>
<td>5.9</td>
<td>6.4%</td>
<td>7.1</td>
<td>6.8%</td>
<td>6.6</td>
<td>6.7%</td>
</tr>
<tr>
<td>AUTO SUPPRESSION</td>
<td>7.6</td>
<td>8.3%</td>
<td>6.7</td>
<td>6.4%</td>
<td>7.9</td>
<td>8.0%</td>
</tr>
<tr>
<td>SMOKE MOVEMENT</td>
<td>8.7</td>
<td>9.5%</td>
<td>8.0</td>
<td>7.7%</td>
<td>7.6</td>
<td>7.7%</td>
</tr>
<tr>
<td>BUILDING STRUCTURE</td>
<td>7.6</td>
<td>8.3%</td>
<td>7.0</td>
<td>6.7%</td>
<td>7.7</td>
<td>7.8%</td>
</tr>
<tr>
<td>EXTERNAL ENVIRONMENT</td>
<td>3.3</td>
<td>3.6%</td>
<td>5.0</td>
<td>4.8%</td>
<td>4.6</td>
<td>4.7%</td>
</tr>
</tbody>
</table>

Note: TACTICS
A = Limit the severity of fire and smoke spread.
B = Provide for successful evacuation of occupants and reduce the rate of casualties and loss of life.
C = Provide for effective fire fighting and rescue operation to reduce the severity of loss and damage.
D = Prevent and control the source of ignition with the fire prevention and protection measures.
E = Upgrading the level of fire safety awareness and practical knowledge.
F = Limit the potential loss with effective maintenance operation, high quality building materials and design.
Table 8.6.1: COMPONENTS A Vs COMPONENTS B

The matrix interaction given in number and percentages between the components has a value of importance of 0 to 10.

Minimum 0, 1, 2, 3, 4, 5, 6, 7, 8, 9 OR 10   Maximum 

<table>
<thead>
<tr>
<th>Minimum</th>
<th>Value Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>not relevant.</td>
</tr>
<tr>
<td>1, 2</td>
<td>minor relation, insignificant contribution</td>
</tr>
<tr>
<td>3, 4</td>
<td>minor relation, significant contribution</td>
</tr>
<tr>
<td>5, 6</td>
<td>moderate relation, significant contribution</td>
</tr>
<tr>
<td>7, 8, 9</td>
<td>major relation and major contribution</td>
</tr>
<tr>
<td>10</td>
<td>direct relation with highest contribution</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPONENTS B</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = BUILDING OCCUPANTS</td>
<td>7.4</td>
<td>6.6</td>
<td>6.0</td>
<td>4.1</td>
<td>5.0</td>
<td>6.9</td>
<td>7.9</td>
<td>8.6</td>
<td>8.0</td>
<td>4.7</td>
<td>5.6</td>
<td>5.1</td>
<td>5.6</td>
<td>2.9</td>
</tr>
<tr>
<td>B = PREPARED FOR FIRE EMERGENCY</td>
<td>7.4</td>
<td>7.7</td>
<td>7.7</td>
<td>4.0</td>
<td>4.7</td>
<td>4.1</td>
<td>4.4</td>
<td>5.3</td>
<td>5.1</td>
<td>4.1</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>C = FIRE PREVENTION</td>
<td>6.6</td>
<td>7.4</td>
<td>5.4</td>
<td>5.4</td>
<td>5.0</td>
<td>8.6</td>
<td>9.1</td>
<td>9.0</td>
<td>9.0</td>
<td>5.3</td>
<td>5.9</td>
<td>5.3</td>
<td>5.3</td>
<td>1.6</td>
</tr>
<tr>
<td>D = INTERNAL ENVIRONMENT</td>
<td>6.0</td>
<td>6.0</td>
<td>6.6</td>
<td>6.1</td>
<td>6.4</td>
<td>5.4</td>
<td>7.9</td>
<td>6.1</td>
<td>6.7</td>
<td>6.3</td>
<td>5.0</td>
<td>2.1</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>E = SERVICES</td>
<td>4.1</td>
<td>5.0</td>
<td>3.1</td>
<td>4.6</td>
<td>5.0</td>
<td>4.3</td>
<td>3.1</td>
<td>5.3</td>
<td>3.9</td>
<td>3.9</td>
<td>4.1</td>
<td>1.6</td>
<td>1.6</td>
<td>1.6</td>
</tr>
<tr>
<td>F = DETECTION</td>
<td>6.9</td>
<td>8.4</td>
<td>4.9</td>
<td>3.0</td>
<td>4.6</td>
<td>8.6</td>
<td>9.1</td>
<td>8.7</td>
<td>5.3</td>
<td>5.1</td>
<td>4.1</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>G = COMMUNICATION AND ALARM</td>
<td>7.9</td>
<td>8.7</td>
<td>4.1</td>
<td>2.9</td>
<td>4.1</td>
<td>5.7</td>
<td>9.0</td>
<td>9.0</td>
<td>4.4</td>
<td>5.1</td>
<td>2.6</td>
<td>4.3</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>H = EGRESS OR ESCAPE</td>
<td>8.9</td>
<td>8.0</td>
<td>2.1</td>
<td>4.9</td>
<td>1.4</td>
<td>2.9</td>
<td>4.1</td>
<td>4.6</td>
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<td>0.7</td>
<td>2.3</td>
<td>4.6</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>I = FIRE FIGHTING</td>
<td>5.9</td>
<td>6.3</td>
<td>4.0</td>
<td>4.0</td>
<td>1.1</td>
<td>1.3</td>
<td>6.1</td>
<td>3.6</td>
<td>2.4</td>
<td>6.7</td>
<td>3.9</td>
<td>3.6</td>
<td>3.6</td>
<td>3.6</td>
</tr>
<tr>
<td>J = PROTECTED AREAS</td>
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<td>1.5</td>
<td>4.4</td>
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<td>7.3</td>
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<td>5.3</td>
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<tr>
<td>K = AUTO SUPPRESSION</td>
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<td>6.3</td>
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<td>5.1</td>
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<td>4.3</td>
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<td>0.7</td>
<td>5.4</td>
<td>6.0</td>
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</tr>
</tbody>
</table>

Note: COMPONENTS A

A = BUILDING OCCUPANTS
B = PREPARED FOR FIRE EMERGENCY
C = FIRE PREVENTION
D = INTERNAL ENVIRONMENT
E = SERVICES
F = DETECTION
G = COMMUNICATION AND ALARM
H = EGRESS OR ESCAPE
I = FIRE FIGHTING
J = PROTECTED AREAS
K = AUTO SUPPRESSION
L = SMOKE MOVEMENT
M = BUILDING STRUCTURE
N = EXTERNAL ENVIRONMENT
Table 8.6.2: COMPONENTS A Vs COMPONENTS B

<table>
<thead>
<tr>
<th>COMPONENTS B</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
<th>K</th>
<th>L</th>
<th>M</th>
<th>N</th>
</tr>
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<td>A = BUILDING OCCUPANTS</td>
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<td>8.2%</td>
<td>10.6%</td>
<td>12.4%</td>
<td>9.6%</td>
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<td>7.0%</td>
<td>4.8%</td>
<td>5.3%</td>
<td>6.9%</td>
<td>4.8%</td>
<td></td>
</tr>
<tr>
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<td>6.3%</td>
<td>4.0%</td>
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<td>7.4%</td>
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<td>11.4%</td>
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<tr>
<td>C = FIRE PREVENTION</td>
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<td>9.4%</td>
<td>8.5%</td>
<td>9.4%</td>
<td>7.6%</td>
<td>4.1%</td>
<td>4.6%</td>
<td>5.5%</td>
<td>8.0%</td>
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<td>7.4%</td>
<td>9.9%</td>
<td>6.7%</td>
<td></td>
</tr>
<tr>
<td>D = INTERNAL ENVIRONMENT</td>
<td>7.6%</td>
<td>7.6%</td>
<td>13.6%</td>
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<tr>
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<td>6.4%</td>
<td>6.4%</td>
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<td>6.6%</td>
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<td>10.8%</td>
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<tr>
<td>F = DETECTION</td>
<td>8.7%</td>
<td>10.7%</td>
<td>10.1%</td>
<td>4.7%</td>
<td>9.2%</td>
<td>14.6%</td>
<td>10.2%</td>
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<td>1.9%</td>
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</tr>
<tr>
<td>G = COMMUNICATION AND ALARM</td>
<td>9.9%</td>
<td>11.1%</td>
<td>8.5%</td>
<td>4.5%</td>
<td>8.2%</td>
<td>9.5%</td>
<td>10.0%</td>
<td>11.2%</td>
<td>6.6%</td>
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<td>3.8%</td>
<td>7.6%</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td>H = EGRESS OR ESCAPE</td>
<td>11.2%</td>
<td>10.2%</td>
<td>4.3%</td>
<td>7.7%</td>
<td>2.8%</td>
<td>4.8%</td>
<td>6.9%</td>
<td>5.7%</td>
<td>9.4%</td>
<td>1.3%</td>
<td>3.3%</td>
<td>8.1%</td>
<td>11.0%</td>
<td></td>
</tr>
<tr>
<td>I = FIRE FIGHTING</td>
<td>7.4%</td>
<td>8.0%</td>
<td>4.7%</td>
<td>6.3%</td>
<td>8.0%</td>
<td>1.8%</td>
<td>2.2%</td>
<td>6.8%</td>
<td>5.4%</td>
<td>4.4%</td>
<td>9.8%</td>
<td>6.9%</td>
<td>17.1%</td>
<td></td>
</tr>
<tr>
<td>J = PROTECTED AREAS</td>
<td>8.4%</td>
<td>6.5%</td>
<td>3.3%</td>
<td>6.9%</td>
<td>6.6%</td>
<td>5.1%</td>
<td>2.9%</td>
<td>8.1%</td>
<td>4.5%</td>
<td>3.9%</td>
<td>6.9%</td>
<td>9.3%</td>
<td>7.6%</td>
<td></td>
</tr>
<tr>
<td>K = AUTO SUPPRESSION</td>
<td>7.6%</td>
<td>8.0%</td>
<td>6.4%</td>
<td>6.9%</td>
<td>10.1%</td>
<td>10.0%</td>
<td>5.7%</td>
<td>7.8%</td>
<td>9.6%</td>
<td>7.0%</td>
<td>10.8%</td>
<td>7.6%</td>
<td>5.2%</td>
<td></td>
</tr>
<tr>
<td>L = SMOKE MOVEMENT</td>
<td>8.3%</td>
<td>5.0%</td>
<td>4.3%</td>
<td>8.5%</td>
<td>4.0%</td>
<td>10.4%</td>
<td>10.6%</td>
<td>9.7%</td>
<td>7.9%</td>
<td>10.6%</td>
<td>5.1%</td>
<td>6.7%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M = BUILDING STRUCTURE</td>
<td>5.5%</td>
<td>4.6%</td>
<td>4.9%</td>
<td>11.0%</td>
<td>8.6%</td>
<td>8.5%</td>
<td>8.3%</td>
<td>8.6%</td>
<td>8.0%</td>
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<td>10.3%</td>
<td>11.7%</td>
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<td></td>
</tr>
<tr>
<td>N = EXTERNAL ENVIRONMENT</td>
<td>2.5%</td>
<td>1.4%</td>
<td>0.6%</td>
<td>6.0%</td>
<td>8.8%</td>
<td>2.8%</td>
<td>2.9%</td>
<td>4.0%</td>
<td>3.9%</td>
<td>2.4%</td>
<td>1.3%</td>
<td>7.9%</td>
<td>10.6%</td>
<td></td>
</tr>
</tbody>
</table>

**Note:** COMPONENTS A
A = BUILDING OCCUPANTS  
B = PREPARED FOR FIRE EMERGENCY  
C = FIRE PREVENTION  
D = INTERNAL ENVIRONMENT  
E = SERVICES  
F = DETECTION  
G = COMMUNICATION AND ALARM  
H = EGRESS OR ESCAPE  
I = FIRE FIGHTING  
J = PROTECTED AREAS  
K = AUTO SUPPRESSION  
L = SMOKE MOVEMENT  
M = BUILDING STRUCTURE  
N = EXTERNAL ENVIRONMENT
8.6.4 Components Vs Components (Step 4)

Now the interaction among the components is given in the Table 8.6.1 for value of importance between 0 to 10 and Table 8.6.2 for percentages values. Again, if any usage of the table is going to be referred (Tables 8.6.1 and 8.6.2), then consideration should only be given to the inter-relationships which are having 5 contribution points and above.

Another step is to bring the whole interaction to be inter-related to one another by introducing the matrix multiplication of the average points given by each level.

8.7 The Matrix Development

The target in designing the check list is to get the agreement on the contribution points for the interaction between the fire safety policy, objectives, tactics and components of the hierarchical framework. The fire safety inter-related contribution relationship given earlier is only between two hierarchies. The values given through the first interaction in the previous tables 8.3, 8.4, 8.5, 8.6.1 and 8.6.2, need to be manipulated to form other values which will bring a complete inter-related contribution values between each of the fourteen components to the overall fire safety policy. Matrix multiplication was used to achieve this purpose. So far, the Group 2 has given values to the objectives-to-policy vector, a tactics-to-objectives matrix, a component-to-tactics matrix and a component-to-components matrix. Now, the same approach of using the multiplication of these matrixes as suggested in the Hospital scheme (10) is applied, a vector for the contribution of tactics-to-policy and another vector of components to overall policy was produced.

Suggestion by Saaty (11):

3 method of column normalisation of a matrix:

i) Set the maximum component equal to 1.
ii) The minimum component equal to 1.
iii) Make the components of any column sum to unity. (most preferably)

It is invariably desirable that the components of the final vector should sum to a fixed constant, e.g.: unity or 100%.
Table 8.7: Matrix Multiplication of Percentages Contribution Matrices.

### Objectives

<table>
<thead>
<tr>
<th>Tactics</th>
<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 8.2</td>
<td>Table 8.1</td>
</tr>
</tbody>
</table>

### Policy

<table>
<thead>
<tr>
<th>Tactics</th>
<th>(A)</th>
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</thead>
<tbody>
<tr>
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<td>18.1% 18%</td>
</tr>
<tr>
<td>2</td>
<td>14.9% 15%</td>
</tr>
<tr>
<td>3</td>
<td>16.9% 17%</td>
</tr>
<tr>
<td>4</td>
<td>17.8% 18%</td>
</tr>
<tr>
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<td>16.2% 16%</td>
</tr>
<tr>
<td>6</td>
<td>16.1% 16%</td>
</tr>
</tbody>
</table>

### Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Policy (V2%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8.3% 8%</td>
</tr>
<tr>
<td>B</td>
<td>9.1% 9%</td>
</tr>
<tr>
<td>C</td>
<td>9.6% 10%</td>
</tr>
<tr>
<td>D</td>
<td>7.6% 8%</td>
</tr>
<tr>
<td>E</td>
<td>6.3% 6%</td>
</tr>
<tr>
<td>F</td>
<td>8.2% 8%</td>
</tr>
<tr>
<td>G</td>
<td>8.1% 8%</td>
</tr>
<tr>
<td>H</td>
<td>5.3% 5%</td>
</tr>
<tr>
<td>I</td>
<td>6.9% 7%</td>
</tr>
<tr>
<td>J</td>
<td>5.9% 6%</td>
</tr>
<tr>
<td>K</td>
<td>6.9% 7%</td>
</tr>
<tr>
<td>L</td>
<td>6.6% 7%</td>
</tr>
<tr>
<td>M</td>
<td>7.5% 7%</td>
</tr>
<tr>
<td>N</td>
<td>3.6% 4%</td>
</tr>
</tbody>
</table>

Note: **TACTICS**

A = Limit the severity of fire and smoke spread.
B = Provide for successful evacuation of occupants and reduce the rate of casualties and loss of life.
C = Provide for effective fire fighting and rescue operation to reduce the severity of loss and damage.
D = Prevent and control the source of ignition with the fire prevention and protection measures.
E = Upgrading the level of fire safety awareness and practical knowledge.
F = Limit the potential loss with effective maintenance operation, high quality building materials and design.

Note: **COMPONENTS**

A = Building Occupants
B = Prepared for Fire Emergency
C = Fire Prevention
D = Internal Environment
E = Services
F = Detection
G = Communication and Alarm
H = Egress or Escape
I = Fire Fighting
J = Protected Areas
K = Auto Suppression
L = Smoke Movement
M = Building Structure
N = External Environment

100%
Figure 8.0: The Matrix Manipulation of the Relative **Percentages** Contribution Vector

**Tactics vs. Objectives** (6 x 6)  
<table>
<thead>
<tr>
<th>18</th>
<th>22</th>
<th>18</th>
<th>16</th>
<th>13</th>
<th>20</th>
</tr>
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<tbody>
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<td>18</td>
<td>16</td>
<td>18</td>
<td>16</td>
<td>17</td>
</tr>
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</table>

**Objectives vs. Policy** (6 x 1)  
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<tr>
<td>14</td>
</tr>
<tr>
<td>13</td>
</tr>
<tr>
<td>14</td>
</tr>
</tbody>
</table>

**Tactics vs. Policy** (6 x 1)  
| 1843 |
| 1514 |
| 1717 |
| 1809 |
| 1645 |
| 1635 |

**Components vs. Tactics** (14 x 6)  
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<th>10</th>
<th>16</th>
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<td>5</td>
<td>3</td>
<td>1</td>
<td>4</td>
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</table>

**Tactics vs. Policy** (14 x 1)  
| 18.1 |
| 14.9 |
| 16.9 |
| 17.8 |
| 16.2 |
| 16.1 |

**Components vs. Policy** (14 x 1)  
| 830.8 |
| 916.9 |
| 968.1 |
| 768.2 |
| 636.5 |
| 820.1 |
| 815.8 |
| 535.9 |
| 690.9 |
| 594.6 |
| 692.5 |
| 667.5 |
| 749.0 |
| 365.4 |

**COMPONENTS**  
A = BUILDING OCCUPANTS  8.26  8  
B = PREPARED FOR FIRE EMERGENCY  9.12  9  
C = FIRE PREVENTION  9.63  9.5  
D = INTERNAL ENVIRONMENT  7.64  8  
E = SERVICES  6.33  6  
F = DETECTION  8.16  8  
G = COMMUNICATION AND ALARM  8.12  8  
H = EGRESS OR ESCAPE  5.33  5  
I = FIRE FIGHTING  6.87  7  
J = PROTECTED AREAS  5.92  6  
K = AUTO SUPPRESSION  6.89  7  
L = SMOKE MOVEMENT CONTROL  6.64  7  
M = BUILDING STRUCTURE  7.45  7.5  
N = EXTERNAL ENVIRONMENT  3.64  4  
\[ \frac{\text{POINTS(%)}}{\text{V2%}} \]
Table 8.8: Matrix Multiplication of Relative Values Contribution Matrices

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<tr>
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<tbody>
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<th>Policy</th>
</tr>
</thead>
<tbody>
<tr>
<td>(14 x 6)</td>
<td>Components Table 8.3 X Tactics (B)</td>
</tr>
</tbody>
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<tr>
<td>2</td>
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<tr>
<td>3</td>
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</tr>
<tr>
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<td>2.839 16.0% 16%</td>
</tr>
<tr>
<td>6</td>
<td>2.852 16.1% 16%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Components</th>
<th>Policy (V3%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>11.6789 7.8% 8%</td>
</tr>
<tr>
<td>B</td>
<td>12.9886 8.7% 9%</td>
</tr>
<tr>
<td>C</td>
<td>13.4061 9.0% 9%</td>
</tr>
<tr>
<td>D</td>
<td>11.1642 7.5% 7.5%</td>
</tr>
<tr>
<td>E</td>
<td>9.3888 6.3% 6%</td>
</tr>
<tr>
<td>F</td>
<td>12.0672 8.1% 8%</td>
</tr>
<tr>
<td>G</td>
<td>12.085 8.1% 8%</td>
</tr>
<tr>
<td>H</td>
<td>8.1703 5.5% 5.5%</td>
</tr>
<tr>
<td>I</td>
<td>10.4037 7.0% 7%</td>
</tr>
<tr>
<td>J</td>
<td>8.7363 5.9% 6%</td>
</tr>
<tr>
<td>K</td>
<td>10.6573 7.2% 7%</td>
</tr>
<tr>
<td>L</td>
<td>10.2013 6.9% 7%</td>
</tr>
<tr>
<td>M</td>
<td>11.2634 7.5% 7.5%</td>
</tr>
<tr>
<td>N</td>
<td>6.6817 4.5% 4.5%</td>
</tr>
</tbody>
</table>

Note: TACTICS
A = Limit the severity of fire and smoke spread.
B = Provide for successful evacuation of occupants and reduce the rate of casualties and loss of life.
C = Provide for effective fire fighting and rescue operation to reduce the severity of loss and damage.
D = Prevent and control the source of ignition with the fire prevention and protection measures.
E = Upgrading the level of fire safety awareness and practical knowledge.
F = Limit the potential loss with effective maintenance operation, high quality building materials and design.

Note: COMPONENTS
A = Building Occupants
B = Prepared for Fire Emergency
C = Fire Prevention
D = Internal Environment
E = Services
F = Detection
G = Communication and Alarm
H = Egress or Escape
I = Fire Fighting
J = Protected Areas
K = Auto Suppression
L = Smoke Movement
M = Building Structure
N = External Environment
**Figure 8.1: The Matrix Manipulation of the Relative Values Contribution Vector**

<table>
<thead>
<tr>
<th>Tactics vs. Objectives (6x6)</th>
<th>Objectives vs. Policy (6x1)</th>
<th>Tactics vs. Policy (6x1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.90 0.96 0.86 0.71 0.59 0.80</td>
<td>0.96</td>
<td>3.2247</td>
</tr>
<tr>
<td>0.96 0.27 0.66 0.67 0.93 0.59</td>
<td>0.70</td>
<td>2.6988</td>
</tr>
<tr>
<td>0.74 0.83 0.81 0.69 0.87 0.66</td>
<td>0.69</td>
<td>3.0008</td>
</tr>
<tr>
<td>0.84 0.86 0.86 0.86 0.60 0.73</td>
<td>0.53</td>
<td>3.1445</td>
</tr>
<tr>
<td>0.87 0.60 0.73 0.73 0.74 0.61</td>
<td>0.50</td>
<td>2.8391</td>
</tr>
<tr>
<td>0.66 0.77 0.76 0.80 0.71 0.71</td>
<td>0.53</td>
<td>2.8523</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Components vs. Tactics (14x6)</th>
<th>Tactics vs. Policy (6x1)</th>
<th>Components vs. Policy (14x1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.59 0.83 0.61 0.73 0.94 0.26</td>
<td>3.2247</td>
<td>11.6789</td>
</tr>
<tr>
<td>0.69 0.87 0.81 0.71 0.96 0.36</td>
<td>2.6988</td>
<td>12.9886</td>
</tr>
<tr>
<td>0.77 0.69 0.57 0.89 0.90 0.70</td>
<td>3.0008</td>
<td>13.4061</td>
</tr>
<tr>
<td>0.71 0.76 0.51 0.66 0.40 0.73</td>
<td>3.1445</td>
<td>11.1642</td>
</tr>
<tr>
<td>0.53 0.53 0.64 0.57 0.16 0.73</td>
<td>2.8391</td>
<td>9.3888</td>
</tr>
<tr>
<td>0.83 0.91 0.77 0.71 0.33 0.51</td>
<td>2.8523</td>
<td>12.0672</td>
</tr>
<tr>
<td>0.73 0.93 0.84 0.59 0.54 0.46</td>
<td>3.2247</td>
<td>11.6789</td>
</tr>
<tr>
<td>0.21 0.96 0.71 0.23 0.39 0.33</td>
<td>2.6988</td>
<td>12.9886</td>
</tr>
<tr>
<td>0.79 0.53 0.97 0.43 0.37 0.39</td>
<td>3.0008</td>
<td>13.4061</td>
</tr>
<tr>
<td>0.59 0.71 0.66 0.21 0.39 0.41</td>
<td>3.1445</td>
<td>11.1642</td>
</tr>
<tr>
<td>0.76 0.67 0.79 0.71 0.14 0.49</td>
<td>2.8391</td>
<td>9.3888</td>
</tr>
<tr>
<td>0.87 0.80 0.76 0.36 0.10 0.54</td>
<td>2.8523</td>
<td>12.0672</td>
</tr>
<tr>
<td>0.76 0.70 0.77 0.47 0.20 0.90</td>
<td>3.2247</td>
<td>11.6789</td>
</tr>
<tr>
<td>0.33 0.50 0.46 0.19 0.60 0.30</td>
<td>2.6988</td>
<td>12.9886</td>
</tr>
</tbody>
</table>

**COMPONENTS**

<table>
<thead>
<tr>
<th>POINTS(%)</th>
<th>V3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = BUILDING OCCUPANTS</td>
<td>7.84</td>
</tr>
<tr>
<td>B = PREPARED FOR FIRE EMERGENCY</td>
<td>8.72</td>
</tr>
<tr>
<td>C = FIRE PREVENTION</td>
<td>9.00</td>
</tr>
<tr>
<td>D = INTERNAL ENVIRONMENT</td>
<td>7.50</td>
</tr>
<tr>
<td>E = SERVICES</td>
<td>6.31</td>
</tr>
<tr>
<td>F = DETECTION</td>
<td>8.10</td>
</tr>
<tr>
<td>G = COMMUNICATION AND ALARM</td>
<td>8.12</td>
</tr>
<tr>
<td>H = EGRESS OR ESCAPE</td>
<td>5.49</td>
</tr>
<tr>
<td>I = FIRE FIGHTING</td>
<td>6.99</td>
</tr>
<tr>
<td>J = PROTECTED AREAS</td>
<td>5.87</td>
</tr>
<tr>
<td>K = AUTO SUPPRESSION</td>
<td>7.16</td>
</tr>
<tr>
<td>L = SMOKE MOVEMENT CONTROL</td>
<td>6.85</td>
</tr>
<tr>
<td>M = BUILDING STRUCTURE</td>
<td>7.56</td>
</tr>
<tr>
<td>N = EXTERNAL ENVIRONMENT</td>
<td>4.49</td>
</tr>
</tbody>
</table>

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8.7.1 Selected Norm Values of the Fire Safety Components

The contribution number that has been chosen for the Norm of the fire safety components for educational establishment buildings are the value contributions vector given as V3% in Figure 8.2. V3% values are chosen instead of V2% values as the norm because the inter-relationships seem to be based on performance values rather than priority. And yet, the difference between V2% and V3% values is very small.

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>POINTS(%)</th>
<th>V3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = BUILDING OCCUPANTS</td>
<td>7.84</td>
<td>8</td>
</tr>
<tr>
<td>B = PREPARED FOR FIRE EMERGENCY</td>
<td>8.72</td>
<td>9</td>
</tr>
<tr>
<td>C = FIRE PREVENTION</td>
<td>9.00</td>
<td>9</td>
</tr>
<tr>
<td>D = INTERNAL ENVIRONMENT</td>
<td>7.50</td>
<td>7.5</td>
</tr>
<tr>
<td>E = SERVICES</td>
<td>6.31</td>
<td>6</td>
</tr>
<tr>
<td>F = DETECTION</td>
<td>8.10</td>
<td>8</td>
</tr>
<tr>
<td>G = COMMUNICATION AND ALARM</td>
<td>8.12</td>
<td>8</td>
</tr>
<tr>
<td>H = EGRESS OR ESCAPE</td>
<td>5.49</td>
<td>5.5</td>
</tr>
<tr>
<td>I = FIRE FIGHTING</td>
<td>6.99</td>
<td>7</td>
</tr>
<tr>
<td>J = PROTECTED AREAS</td>
<td>5.87</td>
<td>6</td>
</tr>
<tr>
<td>K = AUTO SUPPRESSION</td>
<td>7.16</td>
<td>7</td>
</tr>
<tr>
<td>L = SMOKE MOVEMENT CONTROL</td>
<td>6.85</td>
<td>7</td>
</tr>
<tr>
<td>M = BUILDING STRUCTURE</td>
<td>7.56</td>
<td>7.5</td>
</tr>
<tr>
<td>N = EXTERNAL ENVIRONMENT</td>
<td>4.49</td>
<td>4.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>COMPONENTS</th>
<th>POINTS(%)</th>
<th>V3%</th>
</tr>
</thead>
<tbody>
<tr>
<td>O = COMMUNICATION AND ALARM</td>
<td>8.12</td>
<td>8</td>
</tr>
<tr>
<td>P = COMBUSTION PROCESS CONTROL</td>
<td>5.76</td>
<td>5.75</td>
</tr>
<tr>
<td>Q = BUILDING STRUCTURE</td>
<td>7.56</td>
<td>7.5</td>
</tr>
<tr>
<td>R = EXTERNAL ENVIRONMENT</td>
<td>4.49</td>
<td>4.5</td>
</tr>
<tr>
<td>S = EGRESS OR ESCAPE</td>
<td>6.85</td>
<td>6.85</td>
</tr>
<tr>
<td>T = FIRE FIGHTING</td>
<td>4.49</td>
<td>4.5</td>
</tr>
<tr>
<td>U = PROTECTED AREAS</td>
<td>5.87</td>
<td>5.5</td>
</tr>
<tr>
<td>V = AUTO SUPPRESSION</td>
<td>7.16</td>
<td>7</td>
</tr>
<tr>
<td>W = SMOKE MOVEMENT CONTROL</td>
<td>6.85</td>
<td>7</td>
</tr>
<tr>
<td>X = BUILDING STRUCTURE</td>
<td>7.56</td>
<td>7.5</td>
</tr>
<tr>
<td>Y = EXTERNAL ENVIRONMENT</td>
<td>4.49</td>
<td>4.5</td>
</tr>
</tbody>
</table>

There are a few particular areas within this contribution points scheme that future research should be undertaken to ensure that the values given are valid. The contribution values are directly taken from the average given points by the experts from the Delphi Group 2 panel members without being normalised to the level of accuracy as suggested by F.J.Dodd and H.A.Donegan (9). It is understood that with normalisation the result or contribution points probably can be used universally. However, since all the members of the Delphi Group 2 are selected professionals who are specifically having a similar interest and knowledge in fire safety engineering, it is expected that the responses will fall within a small range. The results from the responses did show that there is a commonality in giving the scores for the interaction among the hierarchical framework. Of course there are some extreme values given by the members of the Delphi Group 2 and through discussion
and explanation about the uncertainty of the requirements and misunderstanding of
the questions which occurs among the Delphi group members was dispelled during
the meetings. This brought the extreme and average points within a smaller range.
This reduced the size of the extreme band width of responses to a more common
and reliable results. Therefore the average values given through the analysis of the
responses were taken as the contribution values to be manipulated in the matrices
and the vector values V3% are selected to be the Norm Contribution Values for the
safety components. It is assumed that their contribution is adequate to justify the
reliability of the numbers given for the exercise of the component contribution vector
values as valid. If not, the panel members credibility and knowledge in their own field
of interest should still be a question? The method for normalisation is given by
F.J.Dodd and H.A.Donegan(9) as follows:-

2 fundamental ways to achieve normalisation:-

i) Limit the total number of points that participants can award to ensure the
equality of the contributions of all panel and members.

ii) From the administrative view point, we could exert no constraint on the
number of points that could be awarded and normalised the resultant set of
scores using a standard strategy.

   e.g.: For (0,5)

1- Translate the mean of the data to 2.5 (mid-range), or scale the variance to a
standard e.g.: 1.25 or 1.

2- Map the data from (0,5) to (0,5) so image of the mean is 2.5 using function

\[ f(x) = \begin{cases} 
  2.5x \text{ / mean} & \text{for } x < \text{mean} \\
  2.5 & \text{for } x = \text{mean} \\
  2.5 + (x-\text{means}) \times 2.5/ (5 \text{ means}) & \text{for } x > \text{mean} 
\end{cases} \]

The above method of normalisation could help to reduce the bias and improve the
accuracy of responses given by a smaller number of panel members and also any
wide range of responded numbers.

In this context, the given points and the matrix multiplication of relative values
contribution matrices, for the use in the evaluation of fire safety of the educational
establishment in Malaysia can still be accepted, even though the panel members are
from the UK background. The reason is that, most fire safety and constructional
requirements is based on the Uniform Building by-laws 1984, Laws of Malaysia (2)
which is taken to be the Norm are mostly referred to the British Standards and Code
of Practices established in the UK. This is why the document analysis in chapter 3 is considered to be important in the process of producing the evaluation check list and the contribution values numbers of the fire safety components. Yet, it is agreed that most of the expert opinion is only involved in the inter-related relationship of the hierarchical framework which is concerning the universal matters that is typical for any schools or educational establishments towards providing a total safe environment for education.

8.8 Guidelines for the Formation and Designing of the Check List

Apart from the major decision making process that was needed in the risk assessment which has been elaborated in Chapter 6. Decision making also very useful for the local authority and professionals to suggest or decide the best safety system for any trade-off process. The assessment checklist for the evaluation procedure must be produced to enable decision making to be easier by understanding the requirements of the worksheets. It assisted the evaluators in terms of perception percentages or ranking order of 0 to 5 in the final check list using points scheme. However, that is not enough to cover the needs for fire safety evaluation purposes in terms of building performances. There are about eight approaches that were used in this study in order to get the fire safety evaluation procedure that was applicable and reliable:

a) The assessment of the occupants responses  
b) The assessment of the building regulations requirements (Norm)  
c) The assessment of the professional perceptions.  
d) Established the basic reference of the checklist i.e. fire growth, technology availability etc.)  
e) The formation of the checklist.  
f) The method of using the evaluation checklist.  
g) The Points Scheme by expert opinion for numerical evaluation.  
h) The fire model to evaluate the fire engineering design performances.

Mostly the (a), (b), (c), (d), and (g) approaches has been undertaken. So, the following will be concerning the formation of the points scheme evaluation check list, it’s usage and an experimental work of a fire model to evaluate the fire engineering design performances.
8.8.1 Designing The Check List

The burden to design the check lists lies on the designers. A comprehensive knowledge is required to be able to design the check lists. In the earlier meetings with the Delphi Group 1 panel members using the set of questionnaire, a list of buildings areas within the educational buildings involving school buildings has been obtained. The list is based on the importance or priority in terms of fire safety, risk and hazard of the areas being analysed. The priority of the building areas to be analysed are presented in Chapter 5 given by the Delphi Group 1.

A). The building types are divided into 5 categories as explained in paragraph 8.4.2.

Most of the building areas being considered in the survey checklist are enclosed areas with proper walls, ceilings and floors. Only need to evaluate one survey volume at a time by ticking the box corresponding to it. The evaluation can be done in two ways, first with perception percentages and second by survey grading 0 to 5. Both of the scoring from perception percentages and survey grades can each be multiplied with the "N" contribution values which derived from the Delphi group using matrixes multiplication method. "N" contribution values are actually the norm contribution values representing each of the components.

B). Fire Safety Factors

The 14 lists of safety components which are considered to be the safety Norm is the fire safety factors within an area. The safety factors must be assumed to perform 100 % efficiency and reliability when it is needed during any fire emergency or throughout its' existence. Any defects or deficiency on the components to perform as required will resulted a lower perception in contribution by the evaluator. The perception percentages are given based on the reliability and efficiency of the safety components minus any defects that can caused the performance of the safety components to be degrading.
C). Fire Risk Factors

It was said by Alexander (12) that the risk factor is the one that identifies something is in an actual possibility of loss or exposure to loss such as resulted in injuries, deaths, property damage, damage to public image, claims and lawsuits. It is very important to identify risks factors as the actions, decisions and allocations made by the evaluator in the assessment of the components performance will effects the results of the acceptability safety standard about the survey volume and to the whole establishment.

D). Acceptability and Equivalency (12)

The safety and risks factors available within the survey volume need to be balanced with the types of potential fire hazards that may occurred. The acceptable level of safety is usually been defined through legislation and in order to evaluate the performance of safety components for an area will probably not require all the fourteen listed components. So, normally the evaluator is expected to evaluate only the safety component(s) that exist within the survey volume that perhaps help to reduce the risks to property, mission and people to a level which society regards as acceptable. In order to allow equivalency among the safety provision compared to the level of risks and hazards, a common sense is needed from the evaluator to assess the existing safety systems performance which are installed within the same building or nearby rooms to perform to the expected level of safety that may reduced the loss impact to an acceptable standard. Eventhough the safety system is shared by several other rooms. Among the example of safety components that can be shared are such as the communication and alarm system or the fire fighting equipment, which are considered to be contributing towards the overall safety of the survey volume.

It is important to ensure that the common safety system such as a hose reel system or fire extinguishers or P.A. systems installed within a single building could contribute the same level of safety performance expected for rooms on the same floor and these could help to reduce the total expenditure of the school budget by avoiding over spending or over design the safety systems required unless it is found to be inadequate. Another use of equivalency in terms of fire safety evaluation is when the
evaluators or professionals are suggesting for the solutions of the safety requirements where the survey volume seems to be lacking off and categorised as being non-acceptable standard. The process may be called as Trade-off.

8.8.2 Repeatability of the Check List 1

Once the checklist and points scheme for the contribution of the fire safety evaluation has been produced. There is a need to test the repeatability of the evaluation assessment using the checklist to establish the use of the number and reliability of the checklist for other evaluator in dealing with fire safety at schools. All the fourteen fire safety Norms should be considered in an evaluation, the level of fire safety required for that particular area(s) is obtained and conclusion can be made by the evaluator whether it is at the acceptable or non-acceptable safety standard. A repeatability test of the check list is yet to be carried out. However, the consistency in doing the evaluation process is achieved by proper training and well understood the requirements of each of the safety components that need to be assessed in terms of its performances. The guideline notes given could help to ease the training process and improved understanding. The approach of evaluating the space in a building using the similar method of points schemes has proved to be of a successful task in gaining the level of fire safety performances required, repeatability and also the level of acceptable or non-acceptable safety of an area within a building. i.e.: Dwellings (16) and Hospitals Patient Areas (4).

8.8.3 Example of the Check Lists

The checklist can be assessed individually using the example check lists below. The first check list introduced was the observation check list which can be used to assess and evaluate an area in a very straight approach but incomplete. Therefore a step forward of the improved version of the evaluation check list using points scheme on the performances of the fire safety components is shown in the next paragraph. It is called the Fire Safety Evaluation of Building Performance Check list 1.
8.8.4 Observation Checklist

| Number: | 1 |
| Building Type: | A | B | C | D | E | F |
| Building Area: | Sport halls |  |  |  |  |  |
| Components | A. Building Occupants | 90% | 8 | = | 720 |
|  | B. Preparedness For Fire Emergency | 70% | 9 | = | 630 |
|  | C. Fire Prevention | 80% | 9 | = | 720 |
|  | D. Internal Environment | 80% | 7.5 | = | 600 |
|  | E. Services | 80% | 6 | = | 480 |
|  | F. Detection System | 60% | 8 | = | 480 |
|  | G. Communication and Alarm | 50% | 8 | = | 400 |
|  | H. Egress or Escape | 95% | 5.5 | = | 522.5 |
|  | I. Fire Fighting | 50% | 7 | = | 350 |
|  | J. Protected Areas | 85% | 6 | = | 510 |
|  | K. Auto Suppression | 0 | 7 | = | 0 |
|  | L. Smoke Movement/Control | 75% | 7 | = | 525 |
|  | M. Building Structure | 80% | 7.5 | = | 600 |
|  | N. External Environment | 70% | 4.5 | = | 315 |
| Total | = | 7572.5 |

\[
P' = \sum_{n=1}^{14} \frac{P_p \times N_c}{10000} \times 100%\]

Overall Safety Performance \( P' = 75.73\% \) (Acceptable level of safety and the standard is good)
Example 2:

Number: 2

<table>
<thead>
<tr>
<th>Building Type:</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building Area:</td>
<td>Dining Hall</td>
<td>Percentages</td>
<td>Contribution</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Components</td>
<td>(Pp)</td>
<td>(Nc)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Building Occupants</td>
<td>80%</td>
<td>8 = 480</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. Preparedness For Fire Emergency</td>
<td>70%</td>
<td>9 = 630</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C. Fire Prevention</td>
<td>60%</td>
<td>9 = 540</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D. Internal Environment</td>
<td>60%</td>
<td>7.5 = 450</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E. Services</td>
<td>65%</td>
<td>6 = 390</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F. Detection System</td>
<td>55%</td>
<td>8 = 440</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>G. Communication and Alarm</td>
<td>50%</td>
<td>8 = 400</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>H. Egress or Escape</td>
<td>60%</td>
<td>5.5 = 330</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I. Fire Fighting</td>
<td>60%</td>
<td>7 = 420</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>J. Protected Areas</td>
<td>60%</td>
<td>6 = 360</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K. Auto Suppression</td>
<td>0</td>
<td>7 = 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L. Smoke Movement/Control</td>
<td>50%</td>
<td>7 = 350</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M. Building Structure</td>
<td>60%</td>
<td>7.5 = 450</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N. External Environment</td>
<td>60%</td>
<td>4.5 = 270</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total = 5510

\[ P' = \sum_{n=1}^{14} \left( \frac{P_p \times N_c}{10000} \right) \times 100\% \]

Overall Safety Performance \( P' = 55.1\% \) (Acceptable level of safety and the standard is average)

This evaluation observation checklist is considered to be the simplest way to assessed the performance of safety components within an area with adequate experience and having strong knowledge background in fire safety.
However, using the survey grade score between 0 to 5 has given slightly different results compared to the perception percentages contribution calculation using the multiplication of the points scheme. The results seem to fall within the same range of acceptable safety standard and the difference is only in terms of the way the evaluation processes were undertaken, either to use the survey grade [0,5] or the more fine contribution using the perception percentages. It was stated in the hospital scheme (10) that it is important to bear in mind the coarseness of the grading system within which the survey will have been conducted where the 0 to 5 grading giving an accuracy of ± 0.5 on each component.

| Number: | 1 |
| Building Type: | A | B | C | D | E |
| Building Area: | Sport halls | Survey Grade Contribution (Sg) | Contribution Values (Nc) |
| A. Building Occupants | 0 1 2 3 4 5 | 8 = 40 |
| B. Preparedness For Fire Emergency | 0 1 2 3 4 5 | 9 = 36 |
| C. Fire Prevention | 0 1 2 3 4 5 | 9 = 36 |
| D. Internal Environment | 0 1 2 3 4 5 | 7.5 = 30 |
| E. Services | 0 1 2 3 4 5 | 6 = 24 |
| F. Detection System | 0 1 2 3 4 5 | 8 = 24 |
| G. Communication and Alarm | 0 1 2 3 4 5 | 8 = 24 |
| H. Egress or Escape | 0 1 2 3 4 5 | 5.5 = 27.5 |
| I. Fire Fighting | 0 1 2 3 4 5 | 7 = 21 |
| J. Protected Areas | 0 1 2 3 4 5 | 6 = 30 |
| K. Auto Suppression | 0 1 2 3 4 5 | 7 = 0 |
| L. Smoke Movement/Control | 0 1 2 3 4 5 | 7 = 28 |
| M. Building Structure | 0 1 2 3 4 5 | 7.5 = 27.5 |
| N. External Environment | 0 1 2 3 4 5 | 4.5 = 18 |

| Total | 366 |

\[
P' = \frac{\sum_{n=1}^{14} (Sg \times Nc)}{500} \times 100% \]

Overall Safety Performance \[ P' = 73.2 \% \text{ (Acceptable level of safety and the standard is good)} \]
Number: 2

Building Type: A B C D E

Building Area: Dining Hall

Survey Grade

Component | Survey Grade | Contribution
--- | --- | ---
A. Building Occupants | 0 1 2 3 4 5 | 8 = 32
B. Preparedness For Fire Emergency | 0 1 2 3 4 5 | 9 = 36
C. Fire Prevention | 0 1 2 3 4 5 | 9 = 27
D. Internal Environment | 0 1 2 3 4 5 | 7.5 = 22.5
E. Services | 0 1 2 3 4 5 | 6 = 24
F. Detection System | 0 1 2 3 4 5 | 8 = 24
G. Communication and Alarm | 0 1 2 3 4 5 | 8 = 24
H. Egress or Escape | 0 1 2 3 4 5 | 5.5 = 16.5
I. Fire Fighting | 0 1 2 3 4 5 | 7 = 21
J. Protected Areas | 0 1 2 3 4 5 | 6 = 18
K. Auto Suppression | 0 1 2 3 4 5 | 7 = 0
L. Smoke Movement/Control | 0 1 2 3 4 5 | 7 = 21
M. Building Structure | 0 1 2 3 4 5 | 7.5 = 22.5
N. External Environment | 0 1 2 3 4 5 | 4.5 = 13.5

Total = 302

\[
P' = \frac{1}{n} \sum_{i=1}^{14} \left( \frac{Sg \times Nc}{500} \right) \times 100\%
\]

Overall Safety Performance \( P' = 60.4\% \) (Acceptable level of safety and the standard is average).

The followings are the improved check list 1 which has been taken into consideration other useful information that need to be obtained when it is used to evaluate the survey volume. The check list is made easy for the evaluator to do the evaluation based on the types of buildings, areas categorised within the same group, date undertaken and building block, area identification and number of occupants.
<table>
<thead>
<tr>
<th>Components</th>
<th>Percentages 'Perceptions'</th>
<th>'N' Contribution Values</th>
<th>Survey Grade</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Building Occupants</td>
<td></td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>B. Preparedness For Fire Emergency</td>
<td></td>
<td>9 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>C. Fire Prevention</td>
<td></td>
<td>9 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>D. Internal Environment</td>
<td></td>
<td>7.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>E. Services</td>
<td></td>
<td>6 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>F. Detection System</td>
<td></td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>G. Communication and Alarm</td>
<td></td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>H. Egress or Escape</td>
<td></td>
<td>5.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I. Fire Fighting</td>
<td></td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>J. Protected Areas</td>
<td></td>
<td>6 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>K. Auto Suppression</td>
<td></td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>L. Smoke Movement/Control</td>
<td></td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>M. Building Structure</td>
<td></td>
<td>7.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>N. External Environment</td>
<td></td>
<td>4.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

Total Score: 373
### BUILDING TYPE B: ACADEMIC BUILDINGS (II) (MENTAL AND SKILLS DEVELOPMENT)

#### BUILDING AREAS:

<table>
<thead>
<tr>
<th>Building Area</th>
<th>Laboratory (Physics / Biology / Chemistry)</th>
<th>Workshop</th>
<th>Home Science</th>
<th>Computer Room</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Components</strong></td>
<td><strong>Percentages 'Perceptions'</strong></td>
<td><strong>'N' Contribution Values</strong></td>
<td><strong>Survey Grade</strong></td>
<td><strong>Score</strong></td>
</tr>
<tr>
<td>A. Building Occupants</td>
<td>%</td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>B. Preparedness For Fire Emergency</td>
<td>%</td>
<td>9 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>C. Fire Prevention</td>
<td>%</td>
<td>9 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>D. Internal Environment</td>
<td>%</td>
<td>7.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>E. Services</td>
<td>%</td>
<td>6 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>F. Detection System</td>
<td>%</td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>G. Communication and Alarm</td>
<td>%</td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>H. Egress or Escape</td>
<td>%</td>
<td>5.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I. Fire Fighting</td>
<td>%</td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>J. Protected Areas</td>
<td>%</td>
<td>6 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>K. Auto Suppression</td>
<td>%</td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>L. Smoke Movement/Control</td>
<td>%</td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>M. Building Structure</td>
<td>%</td>
<td>7.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>N. External Environment</td>
<td>%</td>
<td>4.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

Total Score: **374**

Notes:
<table>
<thead>
<tr>
<th>Building Areas</th>
<th>Percentage 'Perceptions'</th>
<th>'N' Contribution</th>
<th>Survey Grade</th>
<th>Score</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DORMITORY</td>
<td></td>
<td>8</td>
<td>0 1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. SINGLE ROOM</td>
<td></td>
<td>9</td>
<td>0 1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. PANTRY ROOM</td>
<td></td>
<td>9</td>
<td>0 1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. SICK BAY</td>
<td></td>
<td>7.5</td>
<td>0 1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. WARDEN FLAT</td>
<td></td>
<td>6</td>
<td>0 1 2 3 4 5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Components**

- A. Building Occupants
- B. Preparedness For Fire Emergency
- C. Fire Prevention
- D. Internal Environment
- E. Services
- F. Detection System
- G. Communication and Alarm
- H. Egress or Escape
- I. Fire Fighting
- J. Protected Areas
- K. Auto Suppression
- L. Smoke Movement/Control
- M. Building Structure
- N. External Environment

**Survey Grade**

- 0: Poor
- 1: Fair
- 2: Good
- 3: Very Good
- 4: Excellent
- 5: Outstanding

**Total Score**

- 375
### BUILDING TYPE D: ADMINISTRATIVE AND MANAGERIAL BUILDINGS

#### BUILDING AREAS:
1. GENERAL OFFICE
2. SINGLE OFFICE
3. STAFF ROOM
4. MEETING / CONFERENCE ROOM

#### BUILDING BLOCK:

<table>
<thead>
<tr>
<th>Area Number</th>
<th>Surveyor</th>
<th>No. of Occupants</th>
</tr>
</thead>
</table>

#### Components

<table>
<thead>
<tr>
<th>Components</th>
<th>Percentages 'Perceptions'</th>
<th>'N' Contribution Values</th>
<th>Survey Grade</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Building Occupants</td>
<td>%</td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>B. Preparedness For Fire Emergency</td>
<td>%</td>
<td>9 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>C. Fire Prevention</td>
<td>%</td>
<td>9 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>D. Internal Environment</td>
<td>%</td>
<td>7.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>E. Services</td>
<td>%</td>
<td>6 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>F. Detection System</td>
<td>%</td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>G. Communication and Alarm</td>
<td>%</td>
<td>8 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>H. Egress or Escape</td>
<td>%</td>
<td>5.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>I. Fire Fighting</td>
<td>%</td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>J. Protected Areas</td>
<td>%</td>
<td>6 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>K. Auto Suppression</td>
<td>%</td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>L. Smoke Movement/Control</td>
<td>%</td>
<td>7 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>M. Building Structure</td>
<td>%</td>
<td>7.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
<tr>
<td>N. External Environment</td>
<td>%</td>
<td>4.5 x</td>
<td>0 1 2 3 4 5</td>
<td></td>
</tr>
</tbody>
</table>

#### Total Score

376
### Building Type E: Other Buildings (Spiritual / Physical / Psychological / Business Etc.)

|-----------------|-----------------------|-----------|---------------|-----------------|-------------|---------------------|

**Components**

- **A. Building Occupants**
- **B. Preparedness For Fire Emergency**
- **C. Fire Prevention**
- **D. Internal Environment**
- **E. Services**
- **F. Detection System**
- **G. Communication and Alarm**
- **H. Egress or Escape**
- **I. Fire Fighting**
- **J. Protected Areas**
- **K. Auto Suppression**
- **L. Smoke Movement/Control**
- **M. Building Structure**
- **N. External Environment**

**Percentages**

- A: Building Occupants
- B: Preparedness For Fire Emergency
- C: Fire Prevention
- D: Internal Environment
- E: Services
- F: Detection System
- G: Communication and Alarm
- H: Egress or Escape
- I: Fire Fighting
- J: Protected Areas
- K: Auto Suppression
- L: Smoke Movement/Control
- M: Building Structure
- N: External Environment

**'N' Contribution Values**

- A: 8 x
- B: 9 x
- C: 9 x
- D: 7.5 x
- E: 6 x
- F: 8 x
- G: 8 x
- H: 5.5 x
- I: 7 x
- J: 6 x
- K: 7 x
- L: 7 x
- M: 7.5 x
- N: 4.5 x

**Survey Grade**

- 0 1 2 3 4 5

**Score**

**Notes:**

- Total Score

---

**Table Data:**

- 377
8.8.5 How to Use the Check List: The Fire Safety Evaluation of Building Performance Check list 1

The evaluation of an area can be done through observation of photographs taken or by a walkthrough evaluation assessment. The walkthrough is an important technique that can be used in variety of ways in a building or facility evaluation. This has been suggested by George Baird et.al (14) and the technique can involve users or other interest groups, experts or both. This points scheme evaluation check list 1 is meant to be used by experts or trained evaluators, it is expected to be done in a short time. The points scheme check list is used to obtain rating of the perception percentages or the survey grade. Perhaps there should be a column or space for jotting down any notes or reminder on the check list. During the checking and evaluating, an informal or formal interviews with users on site may be involved and the information obtained through the use of this check list may contribute later in the selection of any improvement or refurbishment or new installation of safety systems into the building area.

The steps are as follows:-

The check list is divided into 3 parts

A. i). Building areas to choose for the evaluation purposes. Only one area at a time by just tick the relevant box, provided. Refer to paragraph 8.7.1 page 374 to 378 for the types of building area.

ii). Other important details required about the survey volume are also provided on top of the check list. Remember that the check list 1 is designed to evaluate the safety performance of a building area.

B. iii). Understand the needs of each safety components given from A-->N on the list by referring to the guideline notes and also using own knowledge on fire safety requirements gained through training courses. Refer to paragraph 8.8.5.3 and Appendix 8.5 for more information on the guidelines provided.

iv). Give the approximation percentages for each components being assessed based on their level of performance by balancing their efficiency or contribution to safety against any defect in terms of technical, workability, reliability and also the level of fire hazard or risk that might be
confronted during emergency. All the perfect components are given 100% perception contribution unless any deficiency of their performance has been spotted. Normally, this is done by professionals or experienced evaluators. To assist in the evaluation process, it is suggested that a camera be used.

C. v). The evaluating process of the components performances is then given a score with the numerical survey grade between 0 to 5. One can use this survey grade to evaluate an area straight away without involving the perception percentages because it is used to confirm the percentages given for each safety components with a ranking number which associated with the performance assessment table. Refer to the paragraph 8.8.5.2. The grade 0 is applied to any of the fourteen safety components that are not applicable to the survey volume.

vi). The number circled in the survey grade for each safety components are then multiplied with the “N” contribution values to give a total score. The overall performance scores can be calculated as:-

1. Using “percentages perception”

\[ P' = \frac{1}{10000} \left( \sum_{n=1}^{14} \frac{Pp \times Nc}{100} \right) \]

2. Using “Survey Grade”

\[ P' = \frac{1}{500} \left( \sum_{n=1}^{14} \frac{Sg \times Nc}{100} \right) \]

where:-
- \( P' \) - Safety performance of an area.
- \( Pp \) - Percentages perception
- \( Nc \) - Norm safety contribution values
- \( Sg \) - Survey grade score

All the fourteen safety components has to be considered in evaluating the areas in a building. Eventhough, some of the components might not be present within the survey volume, the overall result is expected to show the level of safety so that they are within the acceptable safety range or not, based on the current situation of the survey volume. Therefore, if the area is considered safe within the acceptable level of above 40% even without
having certain safety component within it, then that particular safety component(s) may not be needed for the area. But if the same area fall under the not acceptable safety standard of 40% or below then the upgrading task may have to refer to the non-existent safety components or the lowest given scores within the check list. Also, the check list 2 which was introduced in Chapter 7 will assist further assessment on the performance expected of the safety components in more details.

The evaluator sometimes will need to use their imagination and judgement during the evaluation of the survey volume or area particularly dealing with some of the safety components such as the alarm bell which it does not need to be in every room but considered to be good enough if the alarm could be heard loud and clear. And this can still be given 100% or slightly lower scores.

8.8.5.1 The Use of "Trade off" in Points Scheme Evaluation

Example:- In a classroom, let says that the components C is only contributing 4.5% from the assessment which is only half of the actual contribution (9%) for perfect situation of C. Then the improvement that will need to be done to upgrade the system or component within that classroom is with another extra 4.5%. This is for the component C to contribute towards 100% fire safety policy of the educational establishment. However, in another scenario, if the total contribution 9% of that component C can be replaced by other component; i.e.: Component H (5.5%) and Component J (5.9%) to achieve the same policy, then it can be considered adequate. This is what is termed "Trade - Off".

8.8.5.2 Scoring Grade and Percentages on Perceptions

Most of the building areas being considered in the survey checklist are enclosed areas with proper walls, ceilings and floors. Only need to evaluate one survey volume at a time by ticking the box corresponding to it. The evaluation can be done in two ways, first with perception percentages and second by survey grading 0 to 5. Both of the scoring from perception percentages and survey grades can each be
multiplied with the "N" contribution values which derived from the Delphi group using matrix multiplication method. "N" contribution values are actually the norm contribution values representing each of the components.

The whole process in doing the evaluation using the checklist should able to be done quickly and simply. Assuming that all the components of fire safety are giving 100% safety and everything is taken into consideration then the assessing work for the area should based on the loss impact, vulnerability or threat. Therefore the best performance of an area against fire must be of less risk, less threat, less vulnerable to fire exposures and probably high safety measures. However, the worst performance of an area must be of high risk, highly vulnerable towards fire threat and low safety measures.

**Performances Assessment**

Zero, 0 = The component is not available.

Survey Grade:

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Worst</td>
<td>Bad</td>
<td>Average</td>
<td>Good</td>
<td>Very Good</td>
</tr>
</tbody>
</table>

Percentages perceptions:

<table>
<thead>
<tr>
<th>below 30%</th>
<th>30% to 40%</th>
<th>41% to 60%</th>
<th>61% to 80%</th>
<th>81% to 100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Threat</td>
<td>Average Threat</td>
<td>Less Threat</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High Risk</td>
<td>Medium Risk</td>
<td>Low Risk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low Safety</td>
<td>Medium Safety</td>
<td>High Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Highly Vulnerable</td>
<td>(Vulnerability)</td>
<td>Less Vulnerable</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 8.9: Reference for the Performance Scoring and Percentages on Perception

**8.8.5.3 Evaluation Guidelines**

The assessment are done using the available photograph taken during the visits to schools by the researcher. The following are the general guidelines for other evaluator to refer while doing their assessment of the area concern. The guidelines
are based on the 14 components which are considered to be the NORM of fire safety requirement for an area within the educational buildings. There are four parts in the guidelines: Definition, Descriptions, Consideration and Scoring for the Assessment. The whole evaluation guidelines for the fire safety Norm in buildings are presented in Appendix 8.5. An example of one of the component evaluation guidelines are as follows:-

**COMPONENT A: BUILDING OCCUPANTS**

*Definition:* The individual or group of people who occupied a particular building and in this case is the survey volume or area in a building. The educational buildings usually occupied by students, teachers, staffs, general workers, wardens, administrators or principals and even visitors.

*Description:* The assessment should be based on the sensitivity, responses and mobility of the building occupants in reacting towards changes in the normal environment particularly during emergency no matter what ever the activities being carried out within the space volume.

*Consideration:* Abilities in terms of physical, psychological and physiological factors to judge seriousness and to react rationally upon changes in the environment. Alertness and awareness of the safety and danger factors within the space. This involved the condition of the occupants being either awake or asleep. Mobility within spaces and ability to escape or egress during emergency. Assistance should be given to the incapacitated person. Normality of the senses, i.e.: touch, vision, smell and hearing etc. The number of people using the area at a time and the frequency in terms of day, weeks or years etc.

*Assessment:* Make an assessment on the scale 0 to 5, where 5 representing very fast egress or evacuation, 4 = fast, 3 = slow, 2 = very slow and 1 representing the needs of assistant. 0 is showing absent of building occupants. The assessment is for the overall perception of the occupants.

8.9 Conclusion.

The production of the Building Performance Evaluation Points scheme Check List 1 for the Educational Establishment has been undertaken with reference to the Hospital scheme. Consideration has been given to four major parts in order to
produce the points scheme evaluation check list in this chapter. One is the selection of the panel members of the Delphi Group 2. Two, is the information needed for the design requirement of the check list 1 which involved the interaction of the inter-relation between the policy, objectives, tactics and components, the questionnaire design and method to conduct the meetings using Delphi approach. Three, is the formation of the points scheme by matrix multiplication for their interaction relationships and the design of the evaluation check list 1. Four is the method of using the evaluation points scheme check list 1 to evaluate the building areas in a typical school in Malaysia.

In general, the evaluation points scheme check list 1 is easy to use by the experts or by the trained personnel that will be doing the evaluation assessment. There are two ways of giving the evaluation scores either using own percentages perception or survey grade. The percentages perceptions requires more experiences and knowledge about the systems installed and having a very critical number of questions with good observation which is normally done by experts who give a slightly more detail scoring values. Whereas the survey grade values is a little bit rigid in terms of scoring and being used just to get the overall round number of safety contributions that is available within the survey volume. An observation could probably be assisted by taking photographs along with the walkthrough evaluation assessment.

Results of the evaluation can be used for further evaluation of the whole educational establishment in terms of its' acceptability safety standard against fire. The overall results from evaluation of the areas will give the total level of safety for the blocks of building within the school. Each block can then be accumulated its' contributions to safety to form the overall safety of the particular school involved with the survey. Therefore, the overall evaluation of fire safety acceptability standard for a school is obtained. The following are example check lists of the sequence that can be undertaken to evaluate the whole school for its fire safety requirements.
<table>
<thead>
<tr>
<th>District Name</th>
<th>School Name</th>
<th>Block Nos.</th>
<th>Types of Building</th>
<th>Areas</th>
<th>Contribution % Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td></td>
<td>1</td>
<td>A</td>
<td>1. Classroom</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td></td>
<td>2</td>
<td></td>
<td>2. Library</td>
<td></td>
</tr>
<tr>
<td>III</td>
<td></td>
<td>3</td>
<td></td>
<td>3. Computer Room</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td></td>
<td>4</td>
<td></td>
<td>4. Technology Media</td>
<td></td>
</tr>
<tr>
<td>V</td>
<td></td>
<td>5</td>
<td></td>
<td>5. Resource Centre</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td></td>
<td>6</td>
<td>B</td>
<td>1. Laboratory (Biology)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>7</td>
<td></td>
<td>2. Laboratory (Physics)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>8</td>
<td></td>
<td>3. Laboratory (Chemistry)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>9</td>
<td></td>
<td>4. Workshop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td>5. Home Science</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>11</td>
<td></td>
<td>6. Computer Room</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>12</td>
<td>C</td>
<td>1. Dormitory</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>13</td>
<td></td>
<td>2. Single Room</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>14</td>
<td></td>
<td>3. Pantry Room</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4. Sick Bay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5. Warden Flat</td>
<td></td>
</tr>
<tr>
<td>D</td>
<td></td>
<td>1</td>
<td></td>
<td>1. General Office</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>2. Single office</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>3. Staff room</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>4. Meeting/Conference Room</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td></td>
<td>1</td>
<td></td>
<td>1. Mosque/Prayer hall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>2</td>
<td></td>
<td>2. Canteen</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3</td>
<td></td>
<td>3. Dining hall</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>4</td>
<td></td>
<td>4. Assembly hall</td>
<td></td>
</tr>
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<td></td>
<td></td>
<td>5</td>
<td></td>
<td>5. Gymnasium</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td></td>
<td>6. Co-operative shop</td>
<td></td>
</tr>
</tbody>
</table>

**Overall Average of Contribution Values**
References:


16. Shields T.J., "A Fire Safety Evaluation Points Scheme For Dwellings", Faculty of Science and Technology University of Ulster at Jordanstown, (Thesis), 1990.
9.0 Introduction

The performance of a detection system (heat, smoke or flame) in a building is a major determinant of the effectiveness of other fire safety systems. They are very useful to signal the activation of further safety systems. Robert (1) did mention that in most cases the purpose of a fire detection and alarm system is to alert the occupants of a building that an emergency exists and to initiate evacuation. There is already a regulation in the UK that a new house must have a fire detection system. It is expected that detection and alarm systems will be required for all other types of building. A lot of research has been carried out the detection systems and this work is just a follow up research to investigate the optimal location of the fire sensors mounted on a pitched roof in order to obtain the best possible performance. Among other researches that have been carried out were such as Kohyu Satoh (2) who studied the reliability of fire detection in an air-conditioned rooms.

May be by knowing the best location for the detection system on the roof or ceiling in a building will help to reduce the number of detectors to be installed and resulting a big saving on the budget allocation of the establishment particularly in the total cost of the fire safety installation. Yet the required level of fire safety performance can be achieved within the buildings.

In Malaysia schools are given the highest priority by the Government and the standard form of school building plans has been produced. The reasons are to ensure that all the schools could be easily maintained and supervised by the Ministry of Education in terms of sustaining the continuity in the education development and all other aspects in education particularly to achieve what has been planned in the five year plan. Through these exercises and experimental work advice will be available to the education authority to plan the buildings in terms of orientation, openings, detection system, budget allocation and fire safety management.
9.1 Purpose

The experimental work was prepared to cater for 3 main aspects of design considerations of the fire detection systems. The aspects of design consideration are as follows:-(refer to Diagram 9.3)

MODEL 1: Effects of variation of roof pitch angle on the detection time and locations.

MODEL 2: Effects of different compartment volumes on the detection time and locations.

MODEL 3: Effects of variation of height of the floor level to the ceilings on detection time and locations.

Therefore, the overall purposes of the experimental work are based on the application of the detection and fire alarm systems in terms of fire safety design and also to look at the interaction of building orientation and building design as part of the fire safety design. (The performance of a smoke or heat detection system in terms of best optimal location in an open ventilated compartment with pitched roof).

9.2 Objectives:

i. To find the best location for the smoke / heat detection system based on convected heat plus the automatic alarm system on the ceiling and roof with different angle of slopes.

ii. To know the shortest time taken for the sensors (or automatic alarm system) to detect the smoke or heat based on quick temperature response.

iii. The effects of wind or the building's openings on the performance of the detection system. (Based on the building orientation and the slope angle of the roof pitch)
iv. The smoke movement and flows through a ventilated and non-ventilated enclosure.

iv. The worst case of fire or smoke contribution towards the direction of spreading in a non ventilated and an open ventilated enclosure.

The main objective of the study is to determine the best location for detectors based on quick-temperature response sensors with the respect to variation of ceiling slope and sizes of compartment (ventilated and non-ventilated).

9.3 The Construction of The Model

The construction of the experimental model is apparently simple when it already stands on its own in the laboratory. A careful consideration to build a model has to include the following:-

a. The size of the model and to which scale? What will it represent?

b. The materials to build the model in terms of its easiness, flexibility, manageable and how easy to operate (repeatability) the whole experiment.

c. What is it for and are the materials appropriate for the experiment to be carried out?

d. Does there need to be any visual observation on the movement of smoke?

e. Will it cost a lot? How to reduce the cost to a minimum possible?

f. How long is the time needed to build the whole model, setting it up and to complete the whole experiment or tests?

g. What are the results to be expected and the level of accuracy?

9.3.1 Flexibility of the Model

Usually once the model is built a work of improvement on the model will be carried out only if it is needed. In this case, the experiment is in need of a flexible model in order to run smoothly particularly involving a huge number of tests. It is estimated that about 4000 test configurations will have to be done to complete the whole
experiment and it means that the whole parts of the model must be of flexible to any changes based on required compartment sizes and yet strongly hold at it's position.

Example:-

The variables are

- 5 levels of roof inclination degree = 5
- 5 levels of floor height = 5
- 4 different sizes of compartment = 4
- and there are 20 heat source locations on the floor = 20
- with 2 kind of scenarios (ventilated and non-ventilated) = 2

So, the overall number of test configuration are equal to

\[ 5 \times 5 \times 4 \times 20 \times 2 = 4000 \]

The flexibility of the model is also very important for allowing the high temperature within the model to escape and maintain at room temperature before the next test can proceed. Therefore, attempts to design and build a flexible model developed a constructional design as follows:-

a. **Pitched roof**: The angle of the roof pitch can easily be reduced or increased by having moveable segments of roof according to the sizes of compartment needed for the tests. A steel rod is used to make the roof hold steadily at it's angles. In order to make more than one angles, few steel rods that is also moveable with different length are also provided. Besides the pitch roof can be flattened to represent a flat ceiling for the model compartments. There are 5 different degrees of roof inclination 28°, 21°, 14°, 7° and 0°. (Refer to Diagram 9.1 and 9.3)
b. Side walls: There are three parts of side walls that needs to be constructed. The non-ventilated compartments, walls were built by several segments which can easily joined or put into parts by using a strong double sided tape to hold it in position. Any gaps between the joints are covered using fibre tape. However for the ventilated model, the side walls were built by several segments with an opening in the middle. The size of the openings represents an actual window size or an opening for a school building in Malaysia, particularly for the classroom, laboratories, hostels and others. The openings are covered with a plastics screen to represent the louver types window which are commonly used in Malaysia school buildings.

c. Floor: It is constructed using a single flat piece of perspex which can be moved upwards or downwards by a flexible stand which holding the flat piece from
the underneath of the floor base. This is important for the variety levels of compartments' height when it is needed.

![Diagram 9.2: The Construction of the Floor](image)

![Diagram 9.2: The Construction of the Floor](image)

**Diagram 9.2: The Construction of the Floor**

d. Other considerations that were made when designing the model involving the technical support and also the setting of the apparatus. This will be discussed in the following topic.

However, the number of test that has been estimated based on the availability of equipment and capability of the temperature measuring sensors has only covered a total of 435 number of tests. This has been represented in Appendix 9.0.

9.4 **Problem Identification: Technical and Setting Up Consideration**

(Limitation of the Model)

Choosing the appropriate tools for conducting the experiment also need to be carefully studied in order to carry out the experimental process successful. The consideration given on the equipment and apparatus were based on:

i. The nature of the experiment (to be carried out indoor or outdoor, number of people involved with the operational of the experiment, level of risk etc.)

ii. The materials suitable for the purpose of the experiment.
   a) Heat resistance up to 100 degree Celsius.
   b) Durability and manageability.

iii. Size of the Heat source. The heating element is an important part of the whole process particularly to supply a range of temperature different within the
model for the sensors to measure. A preventive measure of heat against the model and accuracy of every attempts of tests during the experiment must also be considered:-

a) How to get a constant heat output every time changing the location of the heat source?

b) What is the source of heat? Is it going to be electricity, chemical reactions or burning fuel, etc.?

c) How to prevent the perspex or model from the extreme temperature of the heat source and the heat absorbing capacity of the surrounding materials which connected directly to the heat source?

The solutions for the problems related to the source of heat are shown clearly in the diagram below:-

![Diagram](image)

**Figure 6.1: The Heat Source and Details Connection**

CERAMIC

PERSPEX

HEATING ELEMENT

PLASTIC TUBE

NEEDLE

HEAT SOURCE

SMOKE SUPPLY (if needed)

Figure 9.0: Heat Source and Details Connection
The drawing of the heat source junction shows how the heat being supplied in to the model constructed using the perspex material. The needle is used to hold still the position of the whole object during the experiment and it is very easy to be disconnected for the next attempt. Moulded ceramic is being used to prevent the perspex material from the hot heated element of the hot air or smoke into the model.

d) Holes size.

Size of the supply hole through the perspex is around 5 - 7 mm. This represents the waste paper basket fire in an enclosure i.e.: Office, room, etc. Considering that the waste paper basket is 300 x 300 mm = 0.09 m². Therefore, by using scale 1:20, the diameter of the holes on the model should be as follows: (Refer to (8))

\[ Q \propto H^{5/2} \]
take the H as any non-dimensional scale factor i.e. the scale

\[ 1:20 \]
\[ = 1/20^{2.5} = 0.00056 \text{ (constant)} \]

So, The new area within the model = 0.09 x 0.00056 m²
\[ = 5.04 \times 10^{-5} \text{ m}^2 \]
and the diameter of the heat source = \[ \sqrt{5.04 \times 10^{-5}} \]
\[ = 7.09 \times 10^{-3} \text{ m} \]
\[ = 7 \text{ mm} \]

e). Experimental Models

The models are representing the actual existing school building in Malaysia using the scale 1:20. The use of the areas are normally quite flexible for example the laboratories, classrooms, or even the dormitories depending on the size required and also the function of the space. Even though the size of the areas can varies but the average taken for the model is (refer to Table 9.1):

Width = 8 metres (fixed) 
Length = 3 metres to 12 metres (depending on the usage) 
Height = 3 metres to 7 metres (including the roof area above the ceiling) 

So the model size is: \[ W \times L \times H \]
\[ = 400 \times 600 \times (150 \text{ to } 350) \text{ mm}. \]
<table>
<thead>
<tr>
<th>Building Type</th>
<th>Consists of Areas (within the same single building block)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hostel (2-storey)</td>
<td>Rooms with double-decker beds/ sick bay/ Metron/ Warden Room/ Prayer Room/ Study Room/ Washing room/ living room/ etc.</td>
</tr>
<tr>
<td></td>
<td>Ref.: (BKB (AP) 400/91/8,9,10)</td>
</tr>
<tr>
<td>Laboratory (3-storey)</td>
<td>Physics, Biology and Chemistry Lab. / Store room/ workshop/ Classroom/ Home science/ Computer room/ Language centre/ Dentist Clinic and Drawing room/ etc.</td>
</tr>
<tr>
<td></td>
<td>Ref.: (BKP(MS) 400/91/19,20,21)</td>
</tr>
<tr>
<td>Classroom (4-storey)</td>
<td>Principal's office/ Administration Office/ Staff room/ Meeting Room/ Dentist Clinic/ Classroom/ etc.</td>
</tr>
<tr>
<td></td>
<td>Ref.: (BKP(SP) 400/91/13)</td>
</tr>
</tbody>
</table>

(Refer to Proposed Standard School Building Plan by JKR Malaysia)

Table 9.0: Proposed Standard School Building Plan

<table>
<thead>
<tr>
<th>HOSTEL (in mm)</th>
<th>LABORATORY (in mm)</th>
<th>CLASSROOM (in mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3000 → 18000</td>
<td>15000</td>
</tr>
<tr>
<td>7500</td>
<td>9500</td>
<td>7500</td>
</tr>
</tbody>
</table>

Various Size:
1. 3000 x 7500 → 3 beds with 1 door (600 mm)
2. 6000 x 7500 → 14 beds with 1 door 1200 mm
3. 9000 x 7500 → 14 or 20 beds with 1 door 600 or 1200 mm.
4. 12000 x 7500 → 18 beds with 2 doors 600 mm
5. 15000 x 7500 → 24 beds with 2 doors 600 mm
6. 18000 x 7500 → 30 beds with 2 doors 1200 mm

One size:
1. 15000 x 9500 → with 2 doors 1200 mm.

Various size:
1. 6000 x 7500 → with 1 door 1200 mm
2. 9000 x 7500 → with 2 doors 1200 mm
3. 12000 x 7500 → with 2 doors 1200 mm
4. 15000 x 7500 → with 2 doors 1200 mm

Table 9.1: The Sizes of the Types of Building in School (Malaysia)

The experiment source of heat is taken to be 10 kW of waste paper basket (3). The range of peak heat output produced is between 4 kW to 18 kW for
waste basket filled with shredded paper. However, with the same 10 kW heat output, it is being calculated using the steady-state equations where if \( r > 0.18H \), the following formula will be used (4):

\[
T_{\text{max}} - T_{\infty} = \frac{5.38}{h} \left( \frac{Q}{r^2} \right)^{2/3} \\
= \frac{5.38}{10/4} \left( \frac{10}{3} \right)^{2/3} \\
= 3.3^\circ C
\]

where \( T \) = temperature is in \( ^\circ C \),
\( r \) = radial position (m)
\( h \) = Ceiling height in (m) and
\( Q_c \) = energy release rate
\( Y \) = detector

Diagram 9.3: Fire plume Interaction With Ceiling(4)

The temperature different between \( T_{\text{max}} \) and \( T_{\infty} \), where a 10 kW waste paper fuel enable to produce around 3.3\( ^\circ \)C temperature sensitivity different in full scale measurement compared to it's environment. Therefore, to create the same temperature different for the model scale 1:20 without being affected by the scaling, the heat output required to be supplied into the model chamber should be as follows:

\[
\left( \frac{Q}{r} \right)^{2/3} = h(T_{\text{max}}-T_{\infty})
\]
\[
= 5.38 \left( \frac{Q}{T_{\text{max}}-T_{\infty}} \right)^{2/3}
\]
\[
Q = \left[ \frac{(0.15)(3.3)}{5.38} \right]^{3/2}
\]
\[
= 5.58 \times 10^{-3} \text{ kW}
\]
\[
= 5.6 \text{ Watt}
\]

Another way is by using the scaling laws(8):

\( U \propto H^{1.5} \), \( V, Q, M \propto H^{5/2} \)

Therefore, if \( Q \propto H^{5/2} \) where \( H \) is equal to a non-dimension factor

\[
= 1/20^{2.5} = 0.00056.
\]

So, for a scale of 1:20 representing a 10 kW waste paper basket fire at full scale will give 10000 x 0.00056 = 5.6 Watt. Therefore, for a small scale
experiment 1:20, the source of heat is estimated to be around 5.6 W. It is representing the source of heat from a rubbish bin fire in an enclosure.

g). Energy Supply
It is expected to be able to supply heat up to 57°C and more up to 80°C. These temperatures should be high enough to trigger the smoke and heat detectors. The thermocouples in the experiments should be able to detect around 57°C. Or where the ambient temperature did not exceed 70°C (5).

iv. Time consumed in doing the whole experiment is usually based on the ability of the researcher to be able to handle every single test and also the process of setting up of the whole equipment for the experiment. The experimental arrangement is shown in Figure 9.1.

Figure 9.1: Photograph showing the whole set up of the experiment model.

9.5 Experimental Procedure

Consideration for time consumed in doing the experimental work includes:-

i. Preliminary design stage and ideas

ii. The availability of the materials to construct the model.

iii. The availability of the equipment or apparatus for the experiment.
iii. The availability of the equipment or apparatus for the experiment.
iv. The availability of assistance given by the technician.
v. The pre-test and repeatability.
vi. The actual experiment.

9.5.1 Preliminary design stage and ideas

The school areas are mostly having human oriented buildings. The detection system installed within the buildings are basically based on flat ceiling and improvement need to be done to cut the cost for it's installation. Even a new computer-vision based security and fire detection system has been built up. This system which is fully automatic and is most suitably used in unmanned buildings (2). Therefore, the ideas are to provide a safer place for the school pupils based on its existing building construction with pitched roof and over hang, standardised but flexible size of space areas and people orientated buildings. However, the effectiveness in terms of fire safety engineering application of the detection system for the school building in Malaysia still need to be examined. So, a normal type of detection system based on heat probably is good enough to start with for the experiment by looking at it's best location on the roof or ceiling and perhaps could result in some cost benefit.

![Diagram of Detection System General Functions]

Figure 9.2: The Detection System General Functions

9.5.2 The availability of the materials to construct the model.

Sometimes researcher will have to find a source of funding to buy the required materials to build up the model for the experiments. The materials properties must be clarified by the expert in order to avoid any kind of wastage.
9.5.3 Materials, Tools and Apparatus

The followings are the equipment needed to start the experimental work:-

A) Materials:-
   I. Perspex
   II. Cement Board or Plywood.
   III. Mounting Board - Black colour
   IV. Plastcine
   V. Tapes/ glue
   VI. Ceramic up to 57°C and above.
   VII. Steel rods.
   VIII. Plastic tubes (several sizes)
   IX. Levelling liquid

B) Tools And Equipment:-
   I. Wind Tunnel
   II. Data Log (BLUE BOX)
   III. Smoke generator and Heating Source
   IV. Thermocouples
   V. Computer - Windmill packages.
   VI. Fans (Variable Speed)
   VII. Watch or Timer
   VIII. Power supply.
   IX. Multimeter for temperature, voltage, ohms and ampere.
       Flow master
   X. Smoke Generator.

9.5.4 The setting up of the equipment or apparatus for the experiment.

To start the experiment, the required equipment or apparatus must be obtained before the test or experimental work can be carried out. Most of the equipment has been gathered from the fire laboratory and is available readily. The experiment was set up as follows:-
<table>
<thead>
<tr>
<th>Items (Apparatus/Equipment)</th>
<th>Components</th>
<th>Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat Source</td>
<td>1. Ceramic Joint (to prevent high temperature against the model)</td>
<td>Plug in the heat source to the ceramic bottom and fastened with the safety pin.</td>
</tr>
<tr>
<td></td>
<td>a) Pin (Fastened)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Insulation (fibre glass)</td>
<td>To protect and keep the heat from escaping through convection from the side of the</td>
</tr>
<tr>
<td></td>
<td></td>
<td>exposed steel of the heat source.</td>
</tr>
<tr>
<td></td>
<td>3. Digital Multi meter</td>
<td>Measure the temperature of the sensor of the heat source. (°C)</td>
</tr>
<tr>
<td></td>
<td>4. DC Multi meter</td>
<td>Measure the Ampere or current supply. (mA)</td>
</tr>
<tr>
<td></td>
<td>5. Slave Master</td>
<td>Measure a) Voltage (V) V=IR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b) Ampere/current</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c) Fan current supply</td>
</tr>
<tr>
<td>Smoke Supply</td>
<td>1. Connecting Tube</td>
<td>To supply smoke</td>
</tr>
<tr>
<td></td>
<td>a) Small Fan (Variable speed)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Smoke Generator</td>
<td>Set the vaporiser to 25 and then switch on the mains. Set the oil pump deliver direction</td>
</tr>
<tr>
<td></td>
<td>a) Smoke Oil</td>
<td>and once the smoke is produced set the vaporiser to lower readings needed. To stop, set the</td>
</tr>
<tr>
<td></td>
<td>b) Vaporiser</td>
<td>oil pump to drain direction and then switch the main off.</td>
</tr>
<tr>
<td></td>
<td>c) Oil pump</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CPU (Computer and Data Logging)</td>
<td>To read and store data.</td>
</tr>
<tr>
<td></td>
<td>2. Docking Unit (Blue Box) Thermocouples (sensors) up to 16 connections.</td>
<td>Connecting sensors to the CPU</td>
</tr>
<tr>
<td></td>
<td>3. Microlink (Windmill Package)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Set-up IML</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ create new set-up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ use co-ordinate system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Click “twice” to set up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Device</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Connection(Thermocouple)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Measurement Transducer: K-type thermocouple(Ni-Cr/Ni-Al)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Input Range/Mode: Automatic</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Engineering Unit: Celsius Scale: 1 (OK)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Windmill Logger</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ File</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Load Hardware Set up</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Connect the related sensor channel ( Blue Box)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Data File. Create Name to data file.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Settings: Read input every sec.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Data File: Save work/data to which directory [A] [C] etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Inputs: Set the required channels.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Start [Append] or [Overwrite]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Stop</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ File: Save logger set up to [C] or [A].</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Microsoft Excel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ Open file.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ C: \ windmill \ filename</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ All Files</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ [File].wlg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>■ [File].wl to get the graph &amp; data to be used with Excel.</td>
<td></td>
</tr>
</tbody>
</table>

Table 9.2: Experimentation Equipment and Procedure
The technician assistance was needed in terms of setting up the model for the experiment which needed a proper skill in dealing with dangerous equipment and giving supervision.

Figure 9.3: Experimental Layout

In order to ensure that the experiment is producing a repeatable result for the same location, a test must be run to see how the experiment might be affected or distracted. The considerations are as follows:-

a. The air movement within the laboratory/surrounding
b. Heating from the hot water pipe
c. Direct sunlight
d. Extractor fan.

The procedure for carrying out the experiment has been set as:-

1. Heat source supply at 6.76 V and $0.852 \rightarrow 0.856$ mA  
   $= 5.623$ W (waste paper basket)
2. Fan set up at 6.04 V and $0.034 \rightarrow 0.036$ mA, the minimum power to start the fan (can be vary) use only if it is needed.
3. Set the heat source location on the floor and then only fixed or set up the thermocouple location on the roof.
4. Set up the data log on the computer.
5. Ensure the heat source readings is below 60°C.
6. Fixed the heat source at the bottom of the model (as a source of heat).
7. Run (start) the data log (computer readings) for 15 seconds. (To get the average temperature of the model internal environment before proceed any further and stop).

8. Switch on the heat supply button.

9. Wait till the heat supply reached 60°C then start the data logging on the computer (Windmill package). Run the Windmill logger for about 5 minutes and stop.

10. The fan button will have to be switched on after 15 seconds from the beginning of the data logging.

11. Once the Windmill reached 5 minutes, stop the data logging readings and switch off the fan and the heat supply.

12. Open the roof top and then disconnect the heat supply from the bottom of the model. Let it cool down naturally.

13. Cool down the model temperature for about 10 minutes or until the heat supply temperature shows below 60.0°C. Then the next experiment can be carried out again by following the steps starting from Number 3 to Number 13.

Note: Stack effect created around the model is being supervised by using 3 sensors measuring outside the model. (ambient H, ambient M and ambient L)

9.5.6 Why running for 5 minutes?

The time for running each experiment has been set for only 5 minutes. The reason is that the purpose of the experiment is to look at the sensitivity of the sensors detecting the heat produced by the heat source in the very early stages of fire development (incipient stage). The highest temperature difference between each point of the sensors location will represent the best location for a detection system according to the fire scenario. The test model configuration is explained in the following paragraph 9.5.5.1 which lead to the decision of 5 minutes experimental running time. Whereas the actual tests undertaken are referred to Appendix 9.1.
9.5.6.1 The location of the measurement points and the location of the heat source

The Roof and sensors location

<table>
<thead>
<tr>
<th>S1°</th>
<th>S2°</th>
<th>S3°</th>
<th>S4°</th>
<th>S5°</th>
<th>S6°</th>
</tr>
</thead>
<tbody>
<tr>
<td>S7°</td>
<td>S8°</td>
<td>S9°</td>
<td>S10°</td>
<td>S11°</td>
<td>S12°</td>
</tr>
</tbody>
</table>

S = Sensor (° it is the measurement points)

The Floor and heat source locations

<table>
<thead>
<tr>
<th>Hs1</th>
<th>Hs2</th>
<th>Hs3</th>
<th>Hs4</th>
<th>Hs5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hs6</td>
<td>Hs7</td>
<td>Hs8</td>
<td>Hs9</td>
<td>Hs10</td>
</tr>
</tbody>
</table>

Hs = Heat Source (° is the location points of the fire)

9.5.6.2 The range of configurations of the test model.

(Refer to Appendix 9.1)
Test 1: Average Temperature-Rise Detected By Sensors After 5 minutes

<table>
<thead>
<tr>
<th>Temperature Profile Based on Sensors Location (300 seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celsius</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Initial</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Series 1 is the initial temperature and Series 2 is the experiment temperature.

Test 2: Average Temperature-Rise Detected By Sensors (After 5 minutes)

<table>
<thead>
<tr>
<th>Temperature Profile Based on Sensors Location On The Roof (300 seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Celsius</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Internal</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

In Test 1 and Test 2 the source of heat is located at Hs5 on the floor (refer to paragraph 9.5.5.1): Since the temperature difference for each of the sensors can be read and calculated even though it is quite small but the 5 minute duration experiment is adequate to be able to justify which sensors can detect significant heat and perhaps set off the alarm, when connected. Sensitivity of the thermocouples seems to be very low and may need much longer time to give a stable readings. The temperature differences will help to determine the best
location for smoke detectors and probably assisting to reduce the false alarm. The location of the sensors which has detected significant heat will later be used to give an overall view of the best location for the fire detection system to be installed at or in the space between the ceiling and the roof, if there are open work ceilings of more than 25% open.

In Test 2: the temperature difference for each of the sensors are also very small. Even the actual time taken for building occupants to evacuate a building once the fire is being detected is about two and a half minutes. This has been suggested by the escape criteria given in Building Bulletin 7(6) and with a protected corridor, a protected stairway and a protected lobby adjoining stairways to a place of safety, a limited period of up to five minutes is acceptable based on the given criteria.

9.5.7 Experiment Minimum Time Interval

The graphs below are showing the reason why each of the experiment can be carried out at 10 minutes intervals. The temperature at each sensor shows the same profile of temperature increased which are between zero to 0.1 degree of Celsius. This condition allows the sensors to cool down sufficiently to give a significant temperature-rise readings for the subsequent experiment. (Please refer to the following graphs).
9.5.8 The actual experiment.

All the test or experiments will be carried out by referring to the following diagrams. The co-ordinate of the sensors and heat source locations also are based on it.
Diagram 9.4: The Divisions of the Model in Terms of Roof Inclination, Floor Level and Compartmentation.

Diagram 9.5: The Heat Source Locations on the Floor Plan.

Agenda: -
- = heat source location

(Compartment)
Diagram 9.6: The Location of Sensors On the Roof Plan.

### 9.5.9 Limitation

1. The entrainment of air flow into the heat source is not considered for the source of heat used. Therefore the usage of air within the compartment for burning process is not calculated.

2. Consideration was only given to the heat supply into the system or area in terms of power(Watts). This has been set to supply a 5.6 Watt heat source in to the model.

3. Consideration also only based on the quickest (best) time to detect the highest temperature of the convection heat flow within the areas. The observation is basically looking at the effectiveness of the sensors to detect the heat source for the period of time. (time and temperature)

4. The model is based on open plan building layout such as classroom, lecture theatre, assembly hall, laboratory, dormitory, and dining halls etc.

5. No mechanical services

6. installed in the room, and it was assumed that the fire happened during absence of the occupants within the area or the occupants are asleep. Therefore, the detector system will be the most essential system to first detect the danger (in the absence of human being.)
Detection system has been known to react in the preliminary stages as one of the essential components for fire safety in any building. The best detection system is the human compared to a mechanical system because they are able to use multiple senses and intelligent processing to detect unwanted fires and probably the significance level of the danger. However, with the absence or incapacitation of people; a reliable automatic fire detection system can be of significant value. The function of a detection system is to provide information to the antifire agent about the presence or probability of an unwanted fire and the antifire agent should be able to make decisions or taking action. The requirements of a detection system can be examined:

A) The New Information Given by The Detection System
B) The Cost of The Actions Taken
C) The Resulting Savings.

Diagram 9.7: Detection System Performance

All the above lead to the following:-(2)

a. Investigating the presence or attribute of fire.

b. Fighting the fire.

c. Escaping.

d. Notifying others or Helping others to escape.

9.7 Experimental Results

The experimental exercise to find out the optimal location of the detector on the ceiling surface of a space volume has been undertaken. Several hundred attempts were carried out and the results are stated in the following graphs.
The experimental work can also be presented using a computer model or
mathematical calculation as it only involved time, distance and speed of movement.
The following is an example of the raw data given by the experimental work using the
Windmill Package.

File opened at 12:35:53 Fri 19 Jul 1996
File closed at 12:44:41 Fri 19 Jul 1996
sensor6
sensor5
sensor4
sensor3
sensor2
sensorl
Intemaltemp
jambientL
ambientM
ambientH
celsius
celsius
celsius
Celsius
celsius
celsius
celsius
Celsius
Celsius
celsius
23.009
22.992
23.059
22.864
22.938
22.592
22.992
21.774
22.373
22.716
23.009
22.992
23.009.
22.664
22.938
22.592
22.975
21.774
22.373
22.718
22.992
22.9
22.847
2
22.9381
22.975
22.592
21.774
22.356
22.701
10
22.97
22.9
22.8
2
22.9
22.
21.774
22.7
22.
1
22.97
23.0
2
22.8
22.9
22.
21.774
22.
22.7
22.97
23.
22.84
2
22.9
22.
21.792
22.7
2
22.953
7
22.987
22.8
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22.992
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22.992
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22.847
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22.701
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22.596
23.031
21.796
22.324
22.741
190
22.997
23.031
31
22.961
22.
23.031 - 22.614
21.777
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236031
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22.9651
23.076 22.329
21.801
22.765
23.009
23.009
22w829
22w9231
23.031 21.796
22.7
- 210
22.971
22.847 - 23.009
22.9181
23.029 - 22.555
21.755
22.718 - 22.302
215
23.022
31 - 234056
22.869
22.961
3
214777
22.76
220
234002
23.056
2.876
23.056
22.96
22.621
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21.7154
22.349
224765
225
22.997
23.031
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22.876
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22.992
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23.014
234014
22.852
22.96
22.555
234029
21.774
22.282
22.7381
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22.977
23.014
21031
22.869
22.997
22.577
23.031
21.777
22.287
22.76
255
23.014
22.977
23.031
22.886
22.96
22.596
23.051
21.7961
22.304
22.76
260
23.031
22.977
23.031
22.869
22.961
22.596
23.051
21.761
22.304
22.76
265
22.977
23.0141
234031
22.869
22.94
22.577
23.031
21.76
22324
22.76
270
22.977
23.031
23.0311
22.869
22.94
22.577
23.051
21.777
22.304
22476
275
22.985
23.056
23.039
22.876
22.965
22.601
23.076
21.784
22.312
224785
280
234002
23.056
23.056
22.893
22.985
22.621
23.093
21.801
22.329
22.785
285
22.977
23.014
23.051
22.852
22494
22.56
23.051
21.801
22.312
22.7851
290
22.96
23.014
23.031
22.869
22.96
22.577
23.068
21476
22.304
22.76
295
224977
23.031
23.031
22.869
22.96
22.577
23.051
21.76
22.287
22.76
300
22.98
23.03
23.04
22.87
22.96
22.58
23.07
21.78
22.31
22.77
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The elapsed time for the test being carried out is stated at the top left hand corner of
the data. The data is read through the sensors which are connected straight into the

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computer and is shown on the screen which can then be save as a file. The data are being analysed using Excel Package and the graphs were plotted as the end results. The reason to analyse the data is to summarise the information collected, so that it can be more readily comprehended and diagrams are therefore often used to make the results more digestible (7).

9.7.1 The Analysis of the Experimental Data

One way of analysing the data is through the use of an average or arithmetic mean, median and standard deviation. The arithmetic mean is to be preferred to the median because it makes more efficient use of the experiment observations; in the mean the size of each observation is included whereas in the median the size is only used to determine whether the observation is larger or smaller than the median. Using mean also can eliminate few of the extreme values which might caused from experimental error. In order to measure the variations of the figures around the average, the appropriate index is the standard deviation for which the basic formula can be computed. The more variable the data, the larger the standard deviation.

\[ s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}} \quad \text{and} \quad \bar{x} = \frac{\sum x}{n} \]

where:
- \( s \) = standard deviation
- \( x \) = observation figure or denotes the variable
- \( \bar{x} \) = arithmetic mean or average figure of the total observation
- \( n \) = total number of observation or the number of values in the addition.
- \( \sum \) = 'add together'

The procedure to analyse the raw data from the experiment is elaborated as follows:

1. Set the configuration for the variables to be analysed either compartmentation size or floor height or roof inclination.
2. Get the relevant test data file.
3. Set the offset for each sensor so that each of them is measuring at same temperature at the start point.
   a) Take the average of the starting temperature readings of all the sensors.
b) Then subtract the average readings with the initial starting temperature of each sensors to get the offset (+/-).

4. Get the average temperature of each point at 300 seconds, calculate the average temperature for the point and then add average temperature with the offset temperature calculated in 3(b).

5. Get the average of the ambient temperature and then use the manipulation below to get the temperature increment of each sensor.

\[
\text{Sensors A \%} = \frac{T_{\text{sensor}} - T_{\text{ambient(ave)}}}{T_{\text{ambient (ave)}}}
\]

The example of the analysis calculation is shown as follow:-

<table>
<thead>
<tr>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
</tr>
</thead>
<tbody>
<tr>
<td>a°C</td>
<td>b°C</td>
<td>c°C</td>
<td>d°C</td>
</tr>
</tbody>
</table>

Therefore, average initial temperature = \( \frac{a + b + c + d}{4} = x \)

So, the offset for all the initial temperature = x-a, x-b, x-c, x-d

= a', b', c', d'

b) Average temperature for each of the sensors over 300 seconds

= \( x_1, x_2, x_3, x_4 \)

c) Actual temperature rise

= \( x_1 + a', x_2 + b', x_3 + c', x_4 + d' \)

d) Temperature Increment \% against ambient = \( Z \)

Ambient (average) = \( To \)

Therefore:-

\[
Z = \frac{(x_1 + a') - To}{To} \%
\]

\[
Z_2 = \frac{(x_1 + b') - To}{To} \%
\]

e) Set the Increment \% with one single temperature as a threshold limit, i.e.: 24°C

Assuming that the internal temperature is not homogenous as there is a direct relationship between the temperature To (external ambient) and Ti (internal) where it does shows that there is a stack effect phenomena within the model. Normally an enclosed structure or building within a controlled environment should not have much influence from the external condition. However the ambient temperature is being measured only to prove that there is a stack effect within the laboratories where the experiment are being carried out. And also showing that the temperature readings is
not fixed to a single point. Therefore looking at the dimensional model, it is best to use the maximum and minimum temperature values or the difference, to show the trend of the heat movement within the model. The reasons is that, the outcome of the experiment will show the highest temperature (heat boost) being sensed over 300 seconds at each sensors. Thus assist in the study of the sensitivity of the location of the sensors on the ceiling.

Basically, in order to measure the general level of central tendency of the temperature increment of each of the sensors, an average temperature measured over 300 seconds is used. Standardisation of the temperature of each sensors is done through the initial temperature measured by each sensors is being corrected by adding the offset temperature.

The data can also be analysed using Maximum minus Minimum value which could help to eliminate the different between the staring point of the experiment and the end result of the sensing over 300 seconds for each sensor.

9.7.2 Configuration A: The Different in Pitched Roof Inclination Degree

In order to analyse the data, several variables such as the heat source location, compartment size and floor height need to be fixed, while the roof inclination angle is
moved step by step depending on what variables are to be investigated. The pitched roof study is involving the following configurations:

<table>
<thead>
<tr>
<th>Variables</th>
<th>Roof Inclination</th>
<th>R1</th>
<th>R3</th>
<th>R5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Compartment</td>
<td></td>
<td>A</td>
<td>AB</td>
<td>ABC A-D</td>
</tr>
<tr>
<td>Fixed Floor Level at</td>
<td></td>
<td>F1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Refer to the Diagram 9.0, Diagram 9.1 and Diagram 9.2.

Therefore the results from R1Ahs1->h5 test is shown as follows:

Experiment R1Ahs1->h5

<table>
<thead>
<tr>
<th>Internal Average</th>
<th>Temperature average + Offset temperature (Initial average-initial temp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>sensor 1</td>
<td>sensor 2</td>
</tr>
<tr>
<td>22.63</td>
<td>22.26</td>
</tr>
<tr>
<td>23.65</td>
<td>23.04</td>
</tr>
<tr>
<td>23.72</td>
<td>23.12</td>
</tr>
<tr>
<td>23.78</td>
<td>23.21</td>
</tr>
<tr>
<td>23.76</td>
<td>23.29</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Average ambient temperature</th>
<th>Temperature average + Offset temperature (Initial average-initial temp)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>sensor 1</td>
</tr>
<tr>
<td>22.21</td>
<td>r1Ahs1</td>
</tr>
<tr>
<td>23.03</td>
<td>r1Ahs2</td>
</tr>
<tr>
<td>23.10</td>
<td>r1Ahs3</td>
</tr>
<tr>
<td>23.18</td>
<td>r1Ahs4</td>
</tr>
<tr>
<td>23.22</td>
<td>r1Ahs5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Stdv</th>
<th>0.421087</th>
</tr>
</thead>
<tbody>
<tr>
<td>variance</td>
<td>0.177314</td>
</tr>
</tbody>
</table>

Take the ambient to be at 23 Celsius

<table>
<thead>
<tr>
<th>sensor 1</th>
<th>sensor 2</th>
<th>sensor 3</th>
<th>sensor 4</th>
<th>sensor 5</th>
<th>sensor 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>r1Ahs1</td>
<td>2.06%</td>
<td>2.18%</td>
<td>2.18%</td>
<td>2.18%</td>
<td>2.18%</td>
</tr>
<tr>
<td>r1Ahs2</td>
<td>2.50%</td>
<td>2.70%</td>
<td>2.70%</td>
<td>2.60%</td>
<td>2.50%</td>
</tr>
<tr>
<td>r1Ahs3</td>
<td>3.19%</td>
<td>3.29%</td>
<td>3.19%</td>
<td>3.19%</td>
<td>3.19%</td>
</tr>
<tr>
<td>r1Ahs4</td>
<td>3.57%</td>
<td>3.47%</td>
<td>3.47%</td>
<td>3.47%</td>
<td>3.47%</td>
</tr>
<tr>
<td>r1Ahs5</td>
<td>3.57%</td>
<td>3.47%</td>
<td>3.47%</td>
<td>3.47%</td>
<td>3.47%</td>
</tr>
</tbody>
</table>

Final - Initial Temperature in Celsius

<table>
<thead>
<tr>
<th>sensor 1</th>
<th>sensor 2</th>
<th>sensor 3</th>
<th>sensor 4</th>
<th>sensor 5</th>
<th>sensor 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>r1Ahs1</td>
<td>-0.045</td>
<td>0.01</td>
<td>-0.007</td>
<td>0.027</td>
<td>0.007</td>
</tr>
<tr>
<td>r1Ahs2</td>
<td>0.024</td>
<td>0.044</td>
<td>0.076</td>
<td>0.042</td>
<td>0.046</td>
</tr>
<tr>
<td>r1Ahs3</td>
<td>-0.035</td>
<td>-0.049</td>
<td>0.004</td>
<td>0.113</td>
<td>-0.05</td>
</tr>
<tr>
<td>r1Ahs4</td>
<td>-0.016</td>
<td>-0.035</td>
<td>-0.032</td>
<td>0.002</td>
<td>0.242</td>
</tr>
<tr>
<td>r1Ahs5</td>
<td>0.006</td>
<td>0.005</td>
<td>0</td>
<td>-0.035</td>
<td>-0.054</td>
</tr>
</tbody>
</table>

Maximum-Minimum

<table>
<thead>
<tr>
<th>sensor 1</th>
<th>sensor 2</th>
<th>sensor 3</th>
<th>sensor 4</th>
<th>sensor 5</th>
<th>sensor 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>r1Ahs1</td>
<td>0.108</td>
<td>0.128</td>
<td>0.104</td>
<td>0.089</td>
<td>0.099</td>
</tr>
<tr>
<td>r1Ahs2</td>
<td>0.082</td>
<td>0.124</td>
<td>0.135</td>
<td>0.123</td>
<td>0.103</td>
</tr>
<tr>
<td>r1Ahs3</td>
<td>0.084</td>
<td>0.066</td>
<td>0.101</td>
<td>0.246</td>
<td>0.097</td>
</tr>
<tr>
<td>r1Ahs4</td>
<td>0.081</td>
<td>0.081</td>
<td>0.093</td>
<td>0.099</td>
<td>0.21</td>
</tr>
<tr>
<td>r1Ahs5</td>
<td>0.135</td>
<td>0.086</td>
<td>0.069</td>
<td>0.052</td>
<td>0.069</td>
</tr>
</tbody>
</table>
The graph above shows that the temperature dose sensed over a period of 300 seconds by the sensors is mostly follows the movement (location and re-location) of the heat source. The higher heat dose experienced by the sensors directly above the heat supply within the model chamber. However, referred to the rank order of highest temperature sensed by each sensor seems to fall between sensor2 and sensor5 under the pitched roof of the model. It is based both on observation of the above graph with the most high peak along the line and also the frequency of the sensors being chosen as the priority of all the tests with the lowest total. Sensors
which located nearest to the apex of the roof are sensing the highest temperature increment of 2.0% up to 4.0%. The graph of the temperature contour given below also confirmed the areas best for sensor location under the roof surface are between sensor2 until sensor5 which covered the biggest area that received high temperature within the prescribed period of 300 seconds or 5 minutes.
The above graph seems to have two extreme temperature differences but in fact it is referring to the time the test is carried out, external or ambient temperature and also the location where the heat supply is giving it’s input into the chamber. Yet still the sensors close to the apex of the roof show a high concentration of heat.

Overall the test operation on roof R1 with 28° against horizontal slope and compartment size A with heat source located from hs1 to hs5 has given an early indication that from the experimental results, the highest temperature sensed by the sensors location may help to give the overall optimal smoke detector location based on the particular test configuration.

Following are graphs produced by the test R1-->R5Ahs1 for comparison and performance study of the sensors with a different ceiling/roof configurations.
9.7.2.1 Different Roof R1 to R5 with Fixed Compartment A and Heat Source Hs1

The above graph is referring to the 5 different angle of roof inclination with a fixed compartment size A and heat source at location hs1. The changes in the roof inclination angle from pitched to a flat roof still maintaining the concentration of heat in the middle part under roof. However, the focal concentration point changed as the roof pitched gradually decrease from R1 to R5. Looking at table below, the roof R4 and R5, the temperature different between the sensors are less compared to the higher pitched roof inclination. It seems that a hot layer of certain temperature has formed underneath the ceiling or roof that maintained the heat from increasing any further and the sensors located in the middle part of the roof are likely to be heated more slowly than any other part as the roof inclination is decreased.

<table>
<thead>
<tr>
<th>Roof</th>
<th>sensor1</th>
<th>sensor2</th>
<th>sensor3</th>
<th>sensor4</th>
<th>sensor5</th>
<th>sensor6</th>
</tr>
</thead>
<tbody>
<tr>
<td>r1ahs1</td>
<td>3.1%</td>
<td>3.2%</td>
<td>3.7%</td>
<td>3.0%</td>
<td>3.1%</td>
<td>3.0%</td>
</tr>
<tr>
<td>r2Ahs1</td>
<td>2.5%</td>
<td>2.9%</td>
<td>2.3%</td>
<td>3.0%</td>
<td>3.1%</td>
<td>2.8%</td>
</tr>
<tr>
<td>r3Ahs1</td>
<td>1.9%</td>
<td>1.8%</td>
<td>1.5%</td>
<td>1.7%</td>
<td>1.6%</td>
<td>1.5%</td>
</tr>
<tr>
<td>r4Ahs1</td>
<td>2.5%</td>
<td>2.1%</td>
<td>2.0%</td>
<td>2.1%</td>
<td>2.1%</td>
<td>2.1%</td>
</tr>
<tr>
<td>r5Ahs1</td>
<td>0.8%</td>
<td>0.7%</td>
<td>0.7%</td>
<td>0.5%</td>
<td>0.7%</td>
<td>0.8%</td>
</tr>
</tbody>
</table>

Table 9.3: Temperature Increment Against Ambient 24°C - Hs1
The heat movement phenomena within the compartment may well be elaborated by the following diagram 9.8.

The heat plume which goes up to the top of the ceiling or under the roof is definitely heating the sensors which are located directly above it. The heat then deflected and start to move horizontally to other areas of low pressure or cold air along the ceiling or roof within the chamber. Since the heat plume is restricted at the end of the ceiling corner, it will flow back as shown as the dotted line in the diagram. The heat plume slowly heats up the sensors (thermocouples) until it reaches certain temperature forming a hot layer beneath the ceiling at constant temperature unless the temperature of the heat plume supplied reaches the hot layer is higher, then only a mixture of that will increased the hot layer temperature to a much higher readings. Therefore the temperature supplied Tg1 is higher than Tg2 which is the temperature of the sensors directly above the plume. The Tg3 is the temperature at the corner of the ceiling which may also represent the hot layer temperature at some point during the experiment. If the temperature of the heat plume that has been deflected and flowing back to the centre is lower than the hot layer temperature and also it's density, the heat plume will gradually fill up the chamber downwards.

So, if the sensors are located in a flat plane, then the temperature rise is coming to a constant as shown in the table above. Whereas the pitched roof will allow the hot plume to travel a little bit further but within the same period of time given, the sensors will be sensing the temperature of the hot layer a much longer time as they were
located at a different level of roof height which gave a different temperature as well. This is explained in the Table 9.3 but only for the higher roof apex such as R1, R2, and R3.

9.7.2.2 Different Roof R1 to R5 with Fixed Compartment A and Heat Source Hs3

The observation on both the above graph and Table 9.4 for different roof R1-->R5 with the heat source at location Hs3 shows that there is a kind of balanced heat being disseminated within the chamber model. As expected that the heat concentration remained in the middle part of the ceiling even when the roof is changing it's inclination degree. The heat plume sensed by the sensors are giving almost an equal temperature different at both side of the heat plume. The above graph shows that at different roof slope, the temperature increment between each sensors that has been set against the ambient temperature of 24°C are decreasing as the roof slope declines to form a flat roof. This particular phenomena is very obvious for the pitched roof R1, R2, R3 involving both test heat source (Hs1) and
heat source (Hs3). So referred to the alarm set temperature for sensors on pitched roof (R1) is between 2.5% to 3.1% which is 0.6% difference but for the flat roof (R5) is between 1.0% to 1.3% with only 0.3% difference. Therefore, for the flat roof, the threshold setting is more likely to be the same but when dealing with pitched roof, one cannot set the threshold for each sensors at the same temperature or time as on the flat roof.

For example, in the above table, if comparison between sensors location are based on same heat dose Hs3 at 24°C for 300 seconds to be 100% as the bench mark, then for sensor 5 on roof R1 will required X seconds.

If take 24°C ambient at 300 sec is considered 100%.

Therefore R1sensor 5 = 2.7%, so at 24°C, X sec \( = \frac{100 \times 300}{102.7} = 292 \text{ sec.} \)

While for R5sensor5 = 1.2% will give \( Y = \frac{100 \times 300}{101.2} = 296 \text{ sec.} \)

It means that the closer a sensor to the apex of a pitched roof, the less time is taken to received the same heat dose compared to a sensor which is on the flat roof. This is due to the surface area that need to be heated by the hot air is smaller for the pitched roof than a flat roof of the same configuration and dimension.

![Diagram showing pitched and flat roofs with sensors and smoke layers](image)

The difference in terms of temperature increment also shows that the same time taken for the heat dose to travel to the sensors within the pitched roof need less time to set the alarm off as the temperature rised to the particular threshold is quicker than a flat roof sensors. It can be referred to the readings of the data print out or calculated as follows:-

If the threshold for an alarm is set at 200 sec after ignition, than the R1 sensor5 with 2.7% temperature increment compared to R5 sensor5 as the bench mark will give \( Y \)
temperature measurement. Let assumed that R5 sensor5 is set to be 70°C at 200 sec, therefore:

\[
\frac{Y}{102.7\%} = \frac{70^\circ C}{100\%}
\]

\[
Y = 71.89 @ 72^\circ C \text{ is the temperature measured for R1 sensor5 at 200 sec.}
\]

9.7.2.3 Different Roof R1 to R5 with Fixed Compartment A and Heat Source Hs5

<table>
<thead>
<tr>
<th>sensors Location</th>
<th>sensor1</th>
<th>sensor2</th>
<th>sensor3</th>
<th>sensor4</th>
<th>sensor5</th>
<th>sensor6</th>
</tr>
</thead>
<tbody>
<tr>
<td>r1Ahs5</td>
<td>4.5%</td>
<td>3.1%</td>
<td>3.6%</td>
<td>4.3%</td>
<td>4.1%</td>
<td>4.4%</td>
</tr>
<tr>
<td>r2Ahs5</td>
<td>3.1%</td>
<td>3.9%</td>
<td>3.6%</td>
<td>4.1%</td>
<td>4.5%</td>
<td>4.6%</td>
</tr>
<tr>
<td>r3Ahs5</td>
<td>1.1%</td>
<td>1.3%</td>
<td>1.4%</td>
<td>1.7%</td>
<td>1.0%</td>
<td>0.5%</td>
</tr>
<tr>
<td>r4Ahs5</td>
<td>0.9%</td>
<td>0.8%</td>
<td>0.9%</td>
<td>0.9%</td>
<td>0.7%</td>
<td>0.6%</td>
</tr>
<tr>
<td>r5Ahs5</td>
<td>2.1%</td>
<td>1.8%</td>
<td>2.3%</td>
<td>2.8%</td>
<td>2.2%</td>
<td>1.8%</td>
</tr>
</tbody>
</table>

Table 9.5: Temperature Increment Against Ambient 24°C - Hs5

The above graph and table for heat source location Hs5, shows that temperature sensed by the sensors which are located directly above or close to the heat source
resulted higher temperature than other sensors. And the calculated temperature increment of each sensor in the table also implied that the hot layer phenomena formation under the roof as the inclination degree declined from pitched to flat do effects the temperature sensed by the sensors throughout the test. The sensors near to the apex of the roof do show the higher temperature increment as explained for test using heat source Hs1 (paragraph 9.7.2.1).

Overall the highest temperature increment for all cases of roof inclination degree R1 to R5 for compartment A with heat source from Hs1 to Hs5, the location between Sensor2 to Sensor5 are more frequently sensed by the sensors and may be the best or the optimal location for smoke/heat detectors. However, if the location of the sensors is based on a flat roof, the sensors are best to be located half way to the centre of the ceiling or roof. Only if the source of fuel and potential hazard is known within the area, than the location for the sensors or detectors should be located directly above them on the ceiling or roof. (Please refer to the following tables of rank order (a) to (e)).

a) Rank Order of Highest Temperature R1Ahs1-5 Tests.

<table>
<thead>
<tr>
<th></th>
<th>sensor1</th>
<th>sensor2</th>
<th>Sensor 3</th>
<th>Sensor 4</th>
<th>sensor5</th>
<th>sensor6</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1Ahs1</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>R1Ahs2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>R1Ahs3</td>
<td>5</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>R1Ahs4</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>R1Ahs5</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>1</td>
</tr>
</tbody>
</table>

b) Rank Order of Highest Temperature R2Ahs1-5 Tests.

<table>
<thead>
<tr>
<th></th>
<th>sensor1</th>
<th>sensor2</th>
<th>sensor3</th>
<th>sensor4</th>
<th>sensor5</th>
<th>sensor6</th>
</tr>
</thead>
<tbody>
<tr>
<td>R2Ahs1</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>R2Ahs2</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>R2Ahs3</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>R2Ahs4</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>R2Ahs5</td>
<td>4</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

19       | 10      | 20      | 13      | 10      | 15      |

c) Rank Order of Highest Temperature R3Ahs1-5 Tests.

<table>
<thead>
<tr>
<th></th>
<th>sensor1</th>
<th>sensor2</th>
<th>sensor3</th>
<th>sensor4</th>
<th>sensor5</th>
<th>sensor6</th>
</tr>
</thead>
<tbody>
<tr>
<td>R3Ahs1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>R3Ahs2</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>R3Ahs3</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>R3Ahs4</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>R3Ahs5</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

17       | 12      | 18      | 12      | 13      | 17      |

422
d) Rank Order of Highest Temperature R4Ahs1-5 Tests.

<table>
<thead>
<tr>
<th>sensor1</th>
<th>sensor2</th>
<th>sensor3</th>
<th>sensor4</th>
<th>sensor5</th>
<th>sensor6</th>
</tr>
</thead>
<tbody>
<tr>
<td>r4Ahs1</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>r4Ahs2</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>r4Ahs3</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>r4Ahs4</td>
<td>5</td>
<td>6</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>r4Ahs5</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>14</td>
<td>19</td>
<td>12</td>
<td>14</td>
</tr>
</tbody>
</table>

e) Rank Order of Highest Temperature R5Ahs1-5 Tests.

<table>
<thead>
<tr>
<th>sensor1</th>
<th>sensor2</th>
<th>sensor3</th>
<th>sensor4</th>
<th>sensor5</th>
<th>sensor6</th>
</tr>
</thead>
<tbody>
<tr>
<td>r5Ahs1</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>r5Ahs2</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>r5Ahs3</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>r5Ahs4</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>r5Ahs5</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>11</td>
<td>17</td>
<td>17</td>
<td>14</td>
</tr>
</tbody>
</table>

where:- 1 = highest priority 2,3,4,5..etc. less priority.

The above rank order can be illustrated as follows:

So the optimal location for these particular test is between sensor2 and sensor5. Some of the experimental data analysis and results are represented in Appendix 9.2.
9.7.3 Configuration B: The Different in Compartmentation Sizes

The tests involved within this study were based on the fixed heat source at a time with fixed roof and changing compartmentation sizes. Comparison are between the roof R1, R3 and R5 as the compartment size change from A to AB, ABC and ABCD.

<table>
<thead>
<tr>
<th>Compartment Sizes</th>
<th>A</th>
<th>AB</th>
<th>ABC</th>
<th>ABCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Heat Source</td>
<td>Hs1</td>
<td>Hs3</td>
<td>Hs8</td>
<td>Hs15</td>
</tr>
<tr>
<td>Roof R1</td>
<td>R3</td>
<td>R5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Floor Height F1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Temperature Profile (Average) for Experiment R5A-ABCDhs3 at 300 seconds after Ignition

The above graphs, both are showing the decrease in terms of temperature sensed by the sensors as the compartment size getting bigger or expanding from A to AB,
ABC and ABCD. The phenomena simply just that temperature is needed to heat up much larger area as the size of the space volume expanding. Therefore, if a detector is set at certain threshold for a particular room, it does not mean that the same threshold limit is apply to other rooms or spaces. Other considerations that one needs to incorporate in installing heat detectors are the room size or dimension, source of fuel that probably will generate enough heat to be detected by the heat sensors and of course the sensitivity of the sensors itself.

The followings graphs are focused on heat contour for each of the experiment as the compartment gets bigger. It does indicated that the temperature of the heat source supplied from the corner of the model only managed to heat the area under the roof up to 0.3 degree Celsius difference. On a flat roof, the sensor seems to affect two parts with high temperature, not in the middle of the compartment but actually at both ends of each corner. This shown clearly by the smaller compartment A. The heat flows along the corner and then through the edge to the other ends of the ceiling which has the low or negative pressure. Then the heat will move slowly towards the middle or centre of the roof. That is the reason why the sensors in compartment A in the centre has the lowest temperature rise. It can be illustrated in the diagram below:

Diagram 9.9: Roof Plan for Compartment A: Smoke/Heat Movement
The above contours are represent the experiment with fixed flat roof R5 and fixed heat source Hs1 with different compartments. The flat roof shows that heat move horizontally to the far end of the roof away from the heat source and gradually move towards the middle part of the roof. The different temperature of hot layer under the roof is given with different tone of darkness referred to the legend. The bigger compartment size, the more heat needed to rise the temperature within the space.
Referring to the above graph Experiment R5Ahs1-hs5, the biggest temperature difference between the sensors are shown by sensor1a and sensor2a compared to the others which is about 0.8 °C. However, this is not the right way to assume that both the sensors are the optimal location for heat detector because each set of experiment may start operation at different temperature based on the time of the day, ambient temperature and how long the sensors have been used throughout the task. Yet, if each of the experiment is being analysed individually, the highest temperature readings from each sensor of the particular experiment is compared to give a better result. In all cases, the above graph is showing that sensor3a and sensor4a are giving the most frequent highest temperature no matter where the heat source is being supplied and for the case of flat roof R5.

Now there are two parts of curve showing the involvement of compartment AB together. The sensors also indicated which sensor is measuring in which part of the roof. The concentration of highest temperature seems to be detected at sensor2a and 3a for roof A but for roof B, sensor2b and 3b at 300 seconds after ignition.
The graphs for experiment R5ABChs1-hs15 and R5ABCDhs1-hs20, both show that the heat supplied into the chamber of a flat roof, do give a constant profile for almost all cases. Basically the sensors located directly above the heat source will show the highest temperature and it means that the location for a smoke / heat detector can be anywhere for a flat roof but it could be slightly different if the size of the
compartment is small and the heat source is from the corner of the room. This can also be represented by the following graphs.
9.7.3.1 Compartment of Different Sizes: Sensors Location and Performance

However, from the above graphs, the experiment R1A-Dhs1-hs20 where the pitched roof R1 with fixed compartment ABCD shows that the heat flows along the pitched roof. The highest temperature concentration is between sensor2 and sensor5 along the compartment. This indicates that in a compartment with pitched roof, a series of sensors or detectors can be arranged along the apex to achieve the earliest possible detection time. In terms of time, the difference between each compartment size from A to ABCD can be observed and comparison can be made through the data tables gathered from the relevant tests. Take the experiment R1 with compartment A to ABCD and fixed heat source Hs3 at 255 seconds after ignition as a comparison. The tables are given below:

<table>
<thead>
<tr>
<th>Time (Sec)</th>
<th>ambient L H</th>
<th>ambient M</th>
<th>ambient M</th>
<th>Internal</th>
<th>sensor1 a</th>
<th>sensor2 a</th>
<th>sensor3 a</th>
<th>sensor4 a</th>
<th>sensor5 a</th>
<th>sensor6 a</th>
<th>R1ABhs3</th>
</tr>
</thead>
</table>
Focused on the same time after ignition at 255 seconds from the above tables, the following data are gathered:-

<table>
<thead>
<tr>
<th>Compartment</th>
<th>Sensor 4</th>
<th>Average Ambient Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) R1Ahs3</td>
<td>23.7°C</td>
<td>22.7°C</td>
</tr>
<tr>
<td>b) R1ABhs3</td>
<td>25.3°C</td>
<td>24.3°C</td>
</tr>
<tr>
<td>c) R1ABCChs3</td>
<td>22.6°C</td>
<td>21.9°C</td>
</tr>
<tr>
<td>d) R1A-Dhs3</td>
<td>19.5°C</td>
<td>19.0°C</td>
</tr>
</tbody>
</table>

If ambient temperature is to be set at 24.3°C where $T_o \approx T_i$, then the new temperature for the same sensor4 at different compartment sizes will result as follows:- (To = outside temperature and Ti = internal temperature)

\[
X_a = \frac{24.3 \times 23.7}{22.7} = 25.37°C
\]
\[
X_b = 25.3°C
\]
\[
X_c = \frac{24.3 \times 22.6}{21.9} = 25.07°C
\]
\[
X_d = \frac{24.3 \times 19.5}{19.0} = 24.89°C
\]

The calculation shows that for the same sensor location, it's temperature will drop as the size of compartment becomes bigger which is supporting the
phenomena that the temperature rise is low if the areas to be covered by the hot air plume is getting larger. Further calculation that has been made on temperature increment percentages for the sensors shown in the table below also parallel with the discussion above.

Based on temperature increment against ambient of 23 °Celsius - R1A-ABCD

<table>
<thead>
<tr>
<th>Roof R1</th>
<th>sensor 1a</th>
<th>sensor 2a</th>
<th>sensor 3a</th>
<th>sensor 4a</th>
<th>sensor 5a</th>
<th>sensor 6a</th>
<th>sensor 2b</th>
<th>sensor 3b</th>
<th>sensor 4b</th>
<th>sensor 5b</th>
<th>sensor 6b</th>
</tr>
</thead>
<tbody>
<tr>
<td>r1Ahs3</td>
<td>3.19%</td>
<td>3.29%</td>
<td>3.19%</td>
<td>3.58%</td>
<td>3.19%</td>
<td>3.19%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r1ABhs3</td>
<td>2.64%</td>
<td>2.28%</td>
<td>3.06%</td>
<td>3.19%</td>
<td>2.43%</td>
<td>2.53%</td>
<td>2.56%</td>
<td>2.54%</td>
<td>2.94%</td>
<td>2.69%</td>
<td>2.41%</td>
</tr>
<tr>
<td>r1ABCs3</td>
<td>2.1%</td>
<td>2.2%</td>
<td>3.3%</td>
<td>3.2%</td>
<td></td>
<td></td>
<td>2.4%</td>
<td>3.2%</td>
<td>2.4%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r1A-Ds3</td>
<td>1.89%</td>
<td>2.01%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2.10%</td>
<td>2.12%</td>
<td>2.12%</td>
<td>2.04%</td>
<td></td>
</tr>
</tbody>
</table>

9.7.3.2 Different Compartment Sizes: Flat Roof R5

Based on temperature increment against ambient of 23 °Celsius R5A-ABCD

<table>
<thead>
<tr>
<th>Roof R5</th>
<th>sensor 1a</th>
<th>sensor 2a</th>
<th>sensor 3a</th>
<th>sensor 4a</th>
<th>sensor 5a</th>
<th>sensor 6a</th>
<th>sensor 2b</th>
<th>sensor 3b</th>
<th>sensor 4b</th>
<th>sensor 5b</th>
<th>sensor 6b</th>
</tr>
</thead>
<tbody>
<tr>
<td>r5Ahs3</td>
<td>0.96%</td>
<td>1.21%</td>
<td>1.12%</td>
<td>1.20%</td>
<td>1.19%</td>
<td>1.01%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>r5ABhs3</td>
<td>2.17%</td>
<td>2.33%</td>
<td>2.15%</td>
<td>2.08%</td>
<td>2.26%</td>
<td>2.20%</td>
<td>2.14%</td>
<td>2.05%</td>
<td>1.98%</td>
<td>1.97%</td>
<td>2.08%</td>
</tr>
<tr>
<td>r5ABCs3</td>
<td>3.26%</td>
<td>2.90%</td>
<td>3.90%</td>
<td>3.45%</td>
<td></td>
<td></td>
<td>3.27%</td>
<td>3.30%</td>
<td>3.33%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>r5A-Ds3</td>
<td>2.56%</td>
<td>2.96%</td>
<td></td>
<td>1.02%</td>
<td>0.18%</td>
<td></td>
<td>0.95%</td>
<td>0.56%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The table above shows the flat roof compartment R5 as it changes its size from size A to ABCD. The temperature increment given within the table indicates that there is an increase in temperature particularly for the sensors located nearer to the heat source such as sensor 1a, sensor 2a, sensor 3a and also most of the sensors located in compartment A and B ceiling. The hot layer phenomena can be achieved quicker in a smaller compartment, therefore the temperature increment for the same sensor location is smaller compared to a bigger compartment. The 300 seconds given time has allowed enough time for the hot plume to heat up the same sensors located near to the heat source but that probably suitable for certain size or space volume which in this case in the compartment size A to ABC. However, for compartment size ABCD, the same heat may need to be supplied for a longer period of time from the heat source in order to increase the sensors temperature by a similar increment to that in a smaller compartment.
9.7.4 Configuration C: The Different in Levels of Height (Floor to Ceiling)

Different Floor Height: Experiment R1F1-F5hs14

<table>
<thead>
<tr>
<th>Sensors Location</th>
<th>Location of the heat source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Area close to the heat source</td>
</tr>
</tbody>
</table>

Different floor: Experiment R1F1-F5hs14

a) Pitched Roof
Both the above graphs refer to experiments with a fixed pitched roof R1 and heat source location 14 but at different floor height to the ceiling from F1(a-d) to F5. Observation made through single sensor 1a on the graph above shows that the temperature increment for the sensor is from the lowest point 1.65% up to the highest point 1.75% when the floor height change from F1(a-d) to F3 against the ambient temperature of 23°C. Please refer also to Diagram 10.0. Still at sensor 1a, the temperature rose as the floor level decreased from F1(250 mm) to F2(225 mm) until F3(200 mm).

The measurement decreases every 25 mm in every change of height. From the top graph, there is a kind of trend that the situation of the temperature maintained at about 0.85% increment within R1F1(a-d)s14 experiment as observation goes along the sensors of that floor level F1(a-d). Overall the other floor levels (F2 up until F5) also increase the temperature above the floor F1. The temperature sensed by the sensors of different floor heights did show some increase as the floor level decreased from F2 until F5 which was between 0.85% to 2.00%. The measurement is not measured from zero point but instead the difference between the highest minus the lowest point of the floor level sensors. The temperature at sensor 6a (refer to graph (a) Pitched Roof) is showing lower temperature is because of it's location was further away from the heat source and at the lowest part of the pitched roof. This perhaps may also be caused by the hot air flow mechanism, turbulence, the changes of the outside ambient temperature during the experiment and also the velocity of hot air within the model as sensed by the sensors which has not been covered within the scope of this study. The flow mechanism of the hot air plume is complicated to explain as it was not measured within the model.

Looking at the graph given below, there are significant curves showing that the heat dose did accumulate and move along the apex of the roof for most test R1F1hs1 to R1F5hs1 which then heated up the sensors. Since the location of the heat source located directly below the sensor 1a and sensor 2a, the temperature increment of the sensors around the areas remain high compared to other sensors. The reason is that the other sensors are located away from the heat source.
Diagram 10.0: The Floor Height to the Ceiling

F1(a-d) = 250 mm to the height of a flat ceiling

F2 = 225 mm  F3 = 200 mm

F4 = 175 mm  F5 = 150 mm

Different Floor Height: Experiment R1F1-F5hs1-hs20

Sensors Location

---

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9.7.4.1 Different Floor Levels with Flat Roof

The fixed flat roof with different floor levels compartment graph below, seems to give a better indication of the temperature profile within the model compared to a pitched roof compartment. It is shown clearly that every time the floor level was make higher from level F1(a-d) to F2 and so on until F5, the temperature difference that was detected by each of the sensor do increases. The temperature seems to spread more evenly throughout the sensors attached to the ceiling of the model. The temperature increased between 1.0% up to 2.5% average for each of the sensor. This is represent by the areas between the two dotted lines.

![Graph showing temperature distribution for different floor levels with flat roof experiment R5F1(a-d)-F5hs20.](image)

Again from the above graph it shows that the flat roof or ceiling will normally have two extreme high temperature at both end part of the ceiling measured over 300 seconds after ignition. The middle part of the ceiling is slightly in a lower temperature then the both end part of the ceiling. It is only significant when the
height of the floor to the ceiling is reduced and adequate heat dose temperature to be supplied. Normally this happened when the heat source is coming from a corner producing a non-symmetrical heat plume. The phenomena of hot layer temperature and the movement of the hot gas under the ceiling are explained in paragraph 9.7.3: Diagram 9.9 and Diagram 9.8.
The above graphs on different floor F1-F5 with fixed flat roof R5 and heat source Hs1 shows that temperature difference occurred as the floor height is reduced similar to the pitched roof experiment. All the sensors have the temperature increment between 1.01% up to 3.14% measured by the percentage difference calculated in the tables below.

<table>
<thead>
<tr>
<th>Floor</th>
<th>sensor1a</th>
<th>sensor2a</th>
<th>sensor4a</th>
<th>sensor5a</th>
<th>sensor2b</th>
<th>sensor3b</th>
</tr>
</thead>
<tbody>
<tr>
<td>r5a-ds1</td>
<td>3.38%</td>
<td>1.97%</td>
<td>0.46%</td>
<td>-0.35%</td>
<td>0.52%</td>
<td>0.21%</td>
</tr>
<tr>
<td>r5f2hs1</td>
<td>1.65%</td>
<td>1.07%</td>
<td>0.85%</td>
<td>0.41%</td>
<td>0.90%</td>
<td>0.69%</td>
</tr>
<tr>
<td>r5f3hs1</td>
<td>1.65%</td>
<td>1.07%</td>
<td>0.85%</td>
<td>0.41%</td>
<td>0.90%</td>
<td>0.69%</td>
</tr>
<tr>
<td>r5f4hs1</td>
<td>3.38%</td>
<td>3.51%</td>
<td>1.92%</td>
<td>0.61%</td>
<td>1.80%</td>
<td>1.41%</td>
</tr>
<tr>
<td>r5f5hs1</td>
<td>2.86%</td>
<td>4.21%</td>
<td>1.85%</td>
<td>0.66%</td>
<td>1.83%</td>
<td>1.51%</td>
</tr>
<tr>
<td>maximum</td>
<td>3.38%</td>
<td>4.21%</td>
<td>1.92%</td>
<td>0.66%</td>
<td>1.83%</td>
<td>1.51%</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.65%</td>
<td>1.07%</td>
<td>0.46%</td>
<td>-0.35%</td>
<td>0.52%</td>
<td>0.21%</td>
</tr>
<tr>
<td>Max.-min</td>
<td>1.73%</td>
<td>3.14%</td>
<td>1.46%</td>
<td>1.01%</td>
<td>1.31%</td>
<td>1.30%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Floor</th>
<th>sensor3c</th>
<th>sensor5c</th>
<th>sensor6c</th>
<th>sensor4d</th>
<th>sensor5d</th>
</tr>
</thead>
<tbody>
<tr>
<td>r5a-ds2O</td>
<td>-0.17%</td>
<td>-1.09%</td>
<td>-1.21%</td>
<td>-0.82%</td>
<td>-1.23%</td>
</tr>
<tr>
<td>r5f2hs2O</td>
<td>0.54%</td>
<td>-0.02%</td>
<td>-0.13%</td>
<td>-0.07%</td>
<td>-0.23%</td>
</tr>
<tr>
<td>r5f3hs2O</td>
<td>0.54%</td>
<td>-0.02%</td>
<td>-0.13%</td>
<td>-0.07%</td>
<td>-0.23%</td>
</tr>
<tr>
<td>r5f4hs2O</td>
<td>1.02%</td>
<td>0.41%</td>
<td>0.22%</td>
<td>0.31%</td>
<td>0.05%</td>
</tr>
<tr>
<td>r5f5hs2O</td>
<td>1.14%</td>
<td>0.55%</td>
<td>0.35%</td>
<td>0.41%</td>
<td>0.16%</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.14%</td>
<td>0.55%</td>
<td>0.35%</td>
<td>0.41%</td>
<td>0.16%</td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.17%</td>
<td>-1.09%</td>
<td>-1.21%</td>
<td>-0.82%</td>
<td>-1.23%</td>
</tr>
<tr>
<td>Max.-min</td>
<td>1.31%</td>
<td>1.64%</td>
<td>1.56%</td>
<td>1.23%</td>
<td>1.39%</td>
</tr>
</tbody>
</table>

9.7.4.2 Detection time based on different floor height

Now the comparison is based on the time each sensor can detect the heat at a particular set threshold. The table below is based on the temperature increment against 23 degree Celsius over 300 seconds, assumed that at 50 degree Celsius the 2.5% temperature increment of sensor 5d of R5a-ds2O is the benchmark, therefore the calculation of the time taken for other sensors to detect similar temperature will be:-

<table>
<thead>
<tr>
<th></th>
<th>sensor3c</th>
<th>sensor5c</th>
<th>sensor6c</th>
<th>sensor4d</th>
<th>sensor5d</th>
</tr>
</thead>
<tbody>
<tr>
<td>r5a-ds20</td>
<td>2.4%</td>
<td>2.2%</td>
<td>2.3%</td>
<td>2.9%</td>
<td>2.5%</td>
</tr>
<tr>
<td>r5f2hs20</td>
<td>2.2%</td>
<td>1.9%</td>
<td>1.8%</td>
<td>2.2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>r5f3hs20</td>
<td>2.2%</td>
<td>1.9%</td>
<td>1.8%</td>
<td>2.2%</td>
<td>2.2%</td>
</tr>
<tr>
<td>r5f4hs20</td>
<td>1.7%</td>
<td>1.3%</td>
<td>1.2%</td>
<td>1.6%</td>
<td>2.0%</td>
</tr>
<tr>
<td>r5f5hs20</td>
<td>1.0%</td>
<td>0.6%</td>
<td>0.5%</td>
<td>1.0%</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

where F1 or (a-d) = 250 mm ceiling height and 

\[ F2 = 225 \text{ mm}, \ F3 = 200 \text{ mm}, \ F4 = 175 \text{ mm and } \ F5 = 150 \text{ mm.} \]
For example: If Floor F1 (a-d) is taken as a benchmark, at 50°C where sensor 5d = 2.5% at 300 seconds, so

At Floor F2 = 2.2%; the time \( X_2 = \frac{2.2 \times 300}{2.5} = 264 \text{ sec.} \)

F3 = 2.2%; the time \( X_3 = 264 \text{ sec.} \)

F4 = 2.0%; the time \( X_4 = \frac{2.0 \times 300}{2.5} = 240 \text{ sec.} \)

F5 = 1.3%; the time \( X_5 = \frac{1.3 \times 300}{2.5} = 156 \text{ sec.} \)

Therefore, the temperature of 50°C can be achieved by the same sensor quicker at the lowest ceiling height of F5 with only 156 sec. However, in the next table below, if the benchmark is changed to sensor 6c at floor F5 with 0.35% increment over 300 seconds with the heat source Hs1, then the time taken for other sensors will be calculated as:

<table>
<thead>
<tr>
<th>sensor</th>
<th>sensor3c</th>
<th>sensor5c</th>
<th>sensor6c</th>
<th>sensor4d</th>
<th>sensor5d</th>
</tr>
</thead>
<tbody>
<tr>
<td>r5a-ds1</td>
<td>-0.17%</td>
<td>-1.09%</td>
<td>-1.21%</td>
<td>-0.82%</td>
<td>-1.23%</td>
</tr>
<tr>
<td>r5f2hs1</td>
<td>0.54%</td>
<td>-0.02%</td>
<td>-0.13%</td>
<td>-0.07%</td>
<td>-0.23%</td>
</tr>
<tr>
<td>r5f3hs1</td>
<td>0.54%</td>
<td>-0.02%</td>
<td>-0.13%</td>
<td>-0.07%</td>
<td>-0.23%</td>
</tr>
<tr>
<td>r5f4hs1</td>
<td>1.02%</td>
<td>0.41%</td>
<td>0.22%</td>
<td>0.31%</td>
<td>0.05%</td>
</tr>
<tr>
<td>r5f5hs1</td>
<td>1.14%</td>
<td>0.55%</td>
<td>0.35%</td>
<td>0.41%</td>
<td>0.16%</td>
</tr>
</tbody>
</table>

Sensor 5d with floor F1 (a-d) \( = -1.23\% \times 300 = \frac{1054 + 300}{0.35} = 1354 \text{ sec.} \)

Sensor 5c with floor F4 \( = 0.41 \times 300 = 351 \text{ sec} \)

This shows that if the heat source is further away from the benchmark, the longer time is needed to achieve the required temperature by the sensor. But the benchmark used should only be applicable to sensors which are located further away from the same heat source of the benchmark and would not be appropriate to apply to the sensors located nearer to the source of heat. So, it is best to take sensor that is having the highest temperature increment percentages and located nearest to the source of heat as the comparison benchmark, only by using such a simple equation.
Basically, the optimal location for smoke/heat sensors with different floor height based on pitched roof is along the half way up of the roof apex as illustrated in the following four graphs. Please refer to page 442 for pitched roof and page 443 for flat roof.

Meanwhile, by referring to the graphs produced using the temperature increment of all the sensors of the flat roof associated with different floor height, they are showing that a constant temperature is spread over the sensors at the lowest height F5 but as the height between floor to ceiling is reduced, the temperature gradually becomes more significant in the middle part of the ceiling. At both end corner parts of the ceiling a higher temperature in most cases was experienced. Therefore, a flat ceiling has a wider area of high temperature concentration compared to the pitched ceiling/roof.
9.8. Discussion

The experiment and test on detection performance mainly requires not only the types of fire or source of heat, but includes the materials available within the space to be tested, the purpose of the room or space, the period of time for early detection, or threshold or time limit before the available fire fighting system is to be operated, and mostly is concerning the limit of lost damage that one could possibly accept for the area. In this case, the 10 kW fire from a paper waste basket has been taken as the limit of heat source supply that will be modelled to produce 5.6 Watt at a smaller scale model of 1:20. No matter how small the temperature is being sensed by the sensors, based on the heat supply, the given temperature increment calculated from the data is adequate to indicate the optimal location of the sensors or smoke detectors on the basis of the given configuration of the model. The earlier a fire can be detected, the more quickly an action can be taken to act against the problems generated by the fire. Some experiments can set the target of sensing time should be no more than 45 seconds and this is more likely to investigate the sensitivity of the sensors within the specified areas. Whereas, this experiment is only trying to generate the assessment guidelines of the detection system performance in terms of the optimal location of the sensors that are representing the detectors. The concentrated areas that are definitely giving the promising outcome and able to detect the existence of danger from smoke and heat, can be used to limit the damage with the installation of sensitive sensors within the detectors or reduce the amount of money spent on number of detection system installed.

The apex of the pitched roof seems to be confirming that the highest temperature areas sensed are around and along the apex of the pitched roof. Therefore the best location of a smoke detectors would be the apex of the roof or ceiling in any degree of inclination. Example: If the expert would like to suggest the detector system to be installed then without financial problems, a trench detector could probably be better than a single point detector. The roof areas covered under the apex that considered to be the best optimal location for the installation of detectors are expanding more in width as the inclination degree reduced.
However for a flat roof or ceiling, the location of the sensors are best to be located anywhere but recommended to be above any probable source of fuel. Therefore, for a flat ceiling or roof, if a detection system is to be installed in the middle part of a flat ceiling, the probability of the sensor detecting the presence of smoke or heat danger is likely to be more significant even though it might delayed a little bit of detection time compared to the one situated at the corner ceiling of an enclosed environment without any influence from external condition.

The materials in a space are often important to know in order to estimate the heat or smoke produced during combustion period. It helps to determine what kind of detection sensors are suitable for that particular environment either they could be smokeless or non-smokeless i.e.: smoke sensors or heat sensors or ultraviolet sensors. Among considerations in designing the optimal location for smoke/heat detector are as follows:-

I). Ceiling height  
ii) Flow rates of the plume of hot air  
iii) Roof angle or slope  
iv) Compartmentation size  
v) Level of sensitivity  
vi) Design fire or heat output  
vii) Ambient temperature or room temperature  
viii) Ventilation or Infiltration  
ix) Openings  
x) Surface materials  

No matter where the heat source is coming from in a controlled environment, the optimal location for a smoke/heat detector attached to the ceiling of a space is anywhere for flat roof and half way up of the ceiling slope for pitched roof condition. However, if the potential source of fuel and heat is known within the space then the detector should be located near to it. Unless a more sensitive sensors are to be used in an area of special needs where the sensors should fulfilled the listed considerations:-
a. based on heat or particles or both or flame
b. detection time
c. space configuration including work partitions

It is not so simple when it involves a pitched roof as one of it's variables. The movement of the hot plume within the model created some uncertainties that are almost inexplicable without a mechanism to measure it. The graphs produced have to be clearly understood with three-dimensional images in mind involving the location of the sensors, heat source at particular test, type of roof and size of the compartment plus the height of the floor to ceiling. The complication can be reduced using more sensors to measure the whole points of the experiment where one of the weaknesses of the experiment undertaken is that the number of sensor points are inadequate for bigger compartment sizes. This resulted some of the graphs produced being inconsistent and they need closer observation and imagination on the actual locations of the sensors and heat sources for every test. Probably with a lot more sensors to detect the heat output on the ceiling/roof a smooth and clearer set of graphs could be produced.

9.9 Conclusion

The results from the experimental analysis assist in the making of a decision for the expert or evaluator in terms of smoke detector location referred to the degree of inclination of the roof from pitch to flat roof type, the level of floors comparing to the height of the detectors on the roof and also the size of compartmentation as it becomes bigger or smaller. All the hypothesis for example: Configuration A : Flat roof to Pitched roof have given a logical pattern of the time for the detectors to be activated such as:-

i. The time taken to detect the present of smoke or heat is shorter from the flat roof or pitched roof particularly for the detection which is directly above the heat source but for the location of the detectors which situated further from the heat source, the pitched roof detectors within an apex seems to be given a quicker response than the detector in the middle part of a flat roof. The
detectors that were located at each end junction between wall and ceiling of flat roof seems to be more responsive compared to the middle one. Therefore, in an area or a room with a flat roof or ceiling, it is best to have two points detectors located at different end corner of the room compared to the single points in the middle of the room where the performance of the detectors system is more efficient. This proposal is good if there is no constraint on finance.

ii. The response time taken to measure the heat for detectors from a smaller to a bigger compartment has proved to be gradually increased and agreed with the hypothesis given earlier. As the compartmentation became bigger and using the same amount of heat output with the same location of the sensors, more time is required to able the sensors achieved the threshold limit. The reason can be simply explained that the travel distance for the hot plume air is further and contact with the building surface along the path that it moves also help to reduce the heat flux before it reaches the particular sensors. However, proper equations suggested in most smoke control studies may be used to investigate in depth the movement of the hot plume air within the model chamber.

iii. The study on optimal location of sensors or detectors based on different floor to ceiling heights may seems to be straight forward in that the temperature will increase as the floor height reduces. Also, the lower the ceiling height, the higher temperature will be sensed by the detectors and the higher level of threshold should be allowed. And the higher the ceiling above the floor, the lower the threshold limit should be set if one need the same time for the alarm to trigger. The trend in which the smoke movement is being controlled was based on a building model experiment. Experimental work can also lead to the appropriate choice of smoke control system such as structural channelling supported by exhaust fan, stack effect and pressurisation.

The whole study of the smoke detector optimal location is to do with the investigation of one of the fire safety component in a great depth on how it is performing and giving the best result for it's purpose. It is also a kind of performance evaluation that probably can be done for other fire safety
components. Further research on other fire safety components in terms of their performance in a particular building should be carried out in the future.

Other future work that can be incorporated with this model could be the ventilated compartment with openings on the compartment walls either by windows or doors. The experimental work can also be presented using a computer model or mathematical calculation as it only involved time, distance and speed of movement or the flow rates.
REFERENCES


CHAPTER 10: CONCLUSION

10.0 Introduction

This chapter is presented to bring all the previous chapters within this thesis to a conclusion of the studies. A word to describe the whole research findings will not be adequate. The areas covered in the development of the fire safety evaluation procedure for the Educational Establishment in Malaysia consist of four major approaches which are organised and supported by several other sub-topics to smooth the flow of the research work undertaken. All the relevant work was presented in the nine chapters of this thesis. Some suggestions for further research within this same field of study are given at the end of this chapter.

10.1 Definition of the Scope of Fire Safety Evaluation Procedure

Evaluation itself is already a huge topic on its own. It can cover several other areas such as quality assurance, quality management, risk assessment and system performance. However, the scope covered in this study is based on the fire safety evaluation procedure for the educational establishment in Malaysia. This basically involved the evaluation of the existing standards or building regulations used in constructing educational buildings particularly involving the residential secondary school in Malaysia that are fully supervised by the Government. In the development of the procedure for the fire safety evaluation, several other areas needed to be approached. These included the contributions of the occupants towards fire safety awareness and establishment of the policy, objectives, tactics, components and sub-components for fire safety in the educational system. Professional judgement contribute to the examination of the perception of fire safety and the proportionate contribution to overall fire safety of the components of fire technology so that the minimum or maximum requirement could be achieved. A method to undertake the task of fire safety evaluation needs to have a procedure so that the evaluation is practicable, reliable and important for the development of fire safety for people and their personal environment.
The procedure developed for the fire safety evaluation of the educational establishment has few category of steps which are stated as follows:

A) The Contributions Given by the Document Analysis
B) The Perception and Requirements of Fire safety by Building Occupants and Professional People.
C) The Acceptable Standard and Performance Level by Evaluation Check Lists and Experimental Analysis.

All the relevant chapters within this thesis are explained with the connection to the steps mentioned above in developing the whole scheme of fire safety evaluation for the educational establishment.

10.2 Step A: The Contribution Through Document Analysis

Most of the category A was covered by Chapter 1.0, 2.0 and 3.0. The fire problems within the establishment were acknowledged and serious effort has been set to overcome the problems using the suggested stages as explained in paragraph 1.6. In order to tackle the problems, knowing exactly the functions of the educational establishment and its background has assisted in the process of information gathering particularly the operation of the educational system, their current problems and future expectations. Therefore the target to solve the problems are guided by the same objectives that were elaborated in Chapter 2.0. Government reports, newspapers and personal visits were among the steps to establish the existence of the fire safety problem. In Chapter 3.0, further steps were the analyses of the regulatory requirements and human behaviour. The fire safety requirements for buildings have been considered in the analysis of the relevant building regulations. The results of the analysis of documents that contain requirements and recommendations were included in the analysis resulting in an interactive framework of risk, loss, cost, safety and requirements.

Basically, human factors are being considered to cater for the need for the building to be designed according to the safety requirements of that particular building occupancy. It is not only for life safety but also emphasises the property protection
objective which can be achieved with a careful study and consideration of the human factors in designing fire safety requirement in buildings.

10.3 Step B: The Perception and Requirements of Fire safety by Building Occupants and Professionals

The use of information gathering from the first three chapters was then applied to the design of the questionnaire for the building occupants of the educational establishments. The feedback from the building occupants were very important for the study of human factors and also to establish the level of fire safety awareness among the target population. In order for the professionals and local authorities to make a decision in solving the fire problems within the establishment, fire risk, fire threat and fire safety system available, must be assessed. The information gathered from both the human behaviour or awareness and the assessment has been incorporated in the design of the questionnaire sent out to the building occupants. Among the criteria that were investigated using the survey research method were attitudes, feelings, past and intended behaviour during fire emergency, knowledge on fire safety, personal characteristics, fire risk, fire threat, priorities and other descriptive items which provide evidence of association.

It was found that some of the respondents were being educated on fire safety within their environment by just answering the questionnaire book. The majority of the respondents were positively aware of the needs for fire safety within their educational establishment boundary and suggested that more training courses and information on fire safety to be disseminated widely to every individual via multi-media systems. The input from the survey could be used for improving the existing safety condition of the establishment and for the newly designed building of the same occupancy and purpose. It could assist the safety engineer or administrator to focus their priority when dealing with fire, based on the rank order established by the occupants themselves. This initiative was done through the questionnaires in Chapter 4.0.

Overall, most of the educational occupancies in Malaysia seems to have a fair knowledge of fire safety awareness to enable them to save own life against the
danger of fire during emergency. The theories and common sense about fire safety is acceptable but not the capability in terms of practical experience in handling fire during initial stage of emergency, knowing the types of fire hazard available within buildings areas, rescue and escape procedure, combustible materials and basic fire fighting using fire extinguishers or hose reels. It was proposed that preparation for more fire drills and fire safety training should be conducted for all the occupants in order to expose them with some ideas on how to handle a fire emergency.

Supervision of activities particularly involved the use of electrical items must be given priority. Reminders (and signage) about the possible danger of fire also need to be disseminated to the occupants more frequently in order to maintain the level of awareness. It also indicated that some work to improve the fire safety management and maintenance work on the fire safety equipment needs to be done, particularly to upgrade the fire safety services and signs within the educational establishment. The questionnaire analysis proved that:-

a. Malaysian students and most educational personnel need to be exposed to more fire safety training and knowledge in order to be prepared to face fire incidents.

b. The level of awareness and knowledge about fire safety among Malaysian is "not " inferior to the level found in the USA and the UK. It just needs to be maintained or even upgraded to a higher level.

c. The actions taken during emergency by the building occupants within the educational establishment has given a thought that the differences in terms of external environment and climatic changes may not required the same fire safety system to be installed within the buildings as would be required in other parts of the world.

d. There is a need to upgrade the fire safety requirement.

In general, the questionnaires were successfully used as:-

i. A survey method

ii. Educational tools on fire safety (dissemination of fire safety knowledge)

iii. Evaluation tools on awareness level (an examination or test)

v. Confirmation of the fire safety system availability and occupants responsibility.

vi. A measurement tool of the acceptance and perception of the users or the occupants of the particular organisation regarding fire safety issues.

The involvement of the building occupants in giving the feedback about the fire safety within the educational establishment also was very helpful to establish the level of response among the occupants towards fire safety with the system installed and also the management of fire safety. Fire Safety Priorities given by the lay people which represented by the questionnaire respondents and Delphi Group 1 are very important to be considered in an evaluation studies particularly the incorporation of their perceptions with the needs for fire safety education and training courses. These required the involvement of information gathering on human factors and behaviour such as physical, psychological and physiological factors, the attitudes, feelings, beliefs, past and intended behaviour, knowledge ownership, personal characteristics and other descriptive items which provide evidence of association. Therefore, the common tool of information gathering on human behaviour during fire emergency for a particular building in used is by sending questionnaire to the building occupants. The input from the survey can even be applied for newly design building of a same occupancy and purpose.

The human factors and behaviour is important consideration in fire safety evaluation study, in order to achieve the objective of life safety. The level of fire safety awareness among the occupants will enable to evaluate the expected performance and ability of the fire safety components available to be used effectively in confronting the fire to the stage where it does not endanger lives and properties or other listed objectives during emergency. The lay people perception by Delphi Group 1 also ranked the fire safety priority as number 3 among 12 other building components after the structural stability and potential risk or accident. Basically, they look at fire safety priority based on their workplace environment and equipment that is applicable for their use during the danger of fire within their premises. By having the feedback and knowledge, the administrators, authorities and professionals will then understand the actual systems to be installed and the steps to tackle the fire problems will be more comprehensive and definite in terms of reliability, practicality and economy.
In the fire safety evaluation procedure, it is necessary to consider both the physical requirements and professional judgement who involved in the design of the building. The feedback and perception from the building occupant who are going to use and occupy the building is vital because the purpose of the building is to create a safe environment for its occupants. The fire safety professionals contribution towards the priority of fire safety are looking at several different scenario which could be based on the “Fire Growth Graph” as a general reference. They do agree that fire safety education and training is the first priority followed by environmental monitoring, detection system, alarm and warning system, etc, which are all arranged and based on the techniques of intervention.

Those are supposedly designed to be effective in confronting with fire emergency according to the level of fire growth seriousness until it reaches the decay stage. (Please refer to Diagram 6.1 page 242). Therefore, the professional will be able to incorporate the human factors into the design of the fire safety requirement of a building with the priority expectation by the lay people or building occupants and the professionals’ experience and knowledge. The outcome will be more practical and applicable to the level of performance needed during fire emergency rather than having a complete set of fire safety components within the building. These components may not be functional or not being used effectively by the untrained occupants in dealing with fire if they depending entirely on fire brigade or the automatic suppression installed, if any.

The lay people are the object under risk and user of the fire safety system where as the fire safety engineers are the designers or bodies who proposed the system to be installed and ensuring the use of the system to the maximum possible during emergency to reduce the loss impact. Therefore, the lay people perceptions on fire safety can be used as a quick reference by the professionals in their fire safety design and assist in their final decision making. As a result, the study of the views given by the lay people and professionals on fire safety priorities are seems to be vital and may well be carried out in analysing the distinctions between them for further work in the evaluation of any buildings particularly dealing with saving human lives and designing people orientated buildings. The whole purpose of the questionnaire either involving building occupants in Chapter 4.0 or the participation of the Delphi Group 1 in Chapter 5.0 can be obtained from the following diagram.
All the studies involving questionnaire either through survey or meetings were set to achieve all the relevant information from the above diagram that will enable to produce a reliable evaluation check list. A broader scope of knowledge and perception based on loss impact, importance and priority of fire safety, the building occupants and building conditions were very useful to cover a comprehensive ideal and yet specific to fire safety requirement for the educational establishment.
The survey questionnaire in Chapter 4.0 was set to have similar objectives as shown in the diagram but in a more flexible approach. It allowed the respondents to feel more free in answering the questions without any structured aims or limitations. However, the involvement of the Delphi Group 1 was arranged to meet in a meeting room with the questions being structured exactly as shown in the diagram above.

The study using the Delphi method has been very successful in achieving a firm consensus from all the members of the group regarding fire safety in educational establishment. The questionnaire has covered most of the human aspects and the Delphi Group has covered the aspects of building and safety requirements within the premises. The fire safety areas dealt with by the Delphi members include the types of buildings, building performances, loss impact, types of premises, the prioritisation and importance of the building areas, types of risk and also the priority of the objectives, tactics and components in achieving the fire safety policy for educational buildings. The summary of the findings are as follows:-

a. School buildings are the most important buildings to be given attention in any community development particularly in view of their contribution towards the development of the nation. The authority should always give priority consideration for the educational buildings in term of their maintenance and renovation work, safety provision and any future development.

b. In the Delphi Group 1 discussion on building performance and fire safety, most of the building performances are related to or contribute towards fire safety to some degree. Fire safety is ranked third of the 14 building performance characteristics. Actually it is very useful as a guideline in dealing with fire safety as part of the total building components and performances requirement.

c. Delphi Group 1 agreed that the residential school is the first priority in the study of fire safety for educational buildings because of the confinement of the area and also time spent by the school children within the establishment. The priority of areas within school's buildings could also helps to make use of the evaluation checklist more efficient when dealing with bigger school buildings where priority and budgets allocation are a principal concern.
e. The types of fire threat, occupant vulnerability (physical, mental and physiological) and aspects of escape capability and also common source(s) of fire accidents were identified and considered by the Delphi Group 1. These established factors can easily be used by the fire safety evaluator of a building with confidence and knowledge to be able to give better judgement and perception of the safety or risk factors within the survey volume in the process of doing evaluation using the available checklist.

f. The fire safety policy, objectives, tactics and components also have been considered in the Delphi group discussion. These are only the perceptions given by members who are mostly not fire safety professionals in terms of qualifications. However, the discussion is to be able to have both the professional and non-professional perceptions on the same topic of fire safety for the educational establishment. The outcome was really impressive in terms of the agreement towards achieving the fire safety policy for the educational establishment. It was agreed that life safety as the main priority objectives in achieving the policy and followed by educational continuity, property protection, educational environment, public anxiety and economy in sequence.

Another major contribution given by Chapter 5.0 was the study of the loss impact of each area within the school boundary. The results of the discussion can ease the administrator in making decision particularly to find solution for relocation of students during the emergency and recovery periods.

Basically this step of evaluation procedure development using the professional consensus and perceptions on fire safety for educational establishment has two separate Delphi Group 1 and Group 2. Both are inter-related where the first group confirming the importance and priority whereas the second group is to enable the used of priorities and importance lists with points scheme into the development of the evaluation check lists. The relationship between the Step A and Step B is illustrated in the following diagram.
The processes of information gathering, professional judgement and perceptions and making an evaluation check list combine to form another useful approach that will ease the development of the evaluation procedure. Similarly the understanding of risk assessment and techniques of fire intervention are important. These were elaborated in Chapter 6.0.

Although the procedure outlined may seem to be complicated, it is be one way to enable an appropriate fire risk assessment system to be developed. The
assessment system that is developed will need to be sufficiently robust for minor modifications to be made without any loss of confidence in the validity of the outcomes of the application of the procedure. Basically the whole study of the risk assessment is about getting the right answer to all the problems stated below:

a. The problems to solve.
b. The building or organisation involved.
c. The areas, occupancy and functions.
d. The Hazard, Risk and Safety Factors.
e. The basic reference for assessment - Fire growth graph as the scenario.
f. The common technology available.
g. The intervention techniques.
h. The information for the formation of evaluation checklist.

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**Diagram:**

- **IDENTIFY**
  - SOURCE OF IGNITION
    - Source of:
      - Heat
      - Fuel
      - Oxygen
      - Chemical reaction
  - RISK (High / Medium / Low)
  - WORK PROCESS OR ACTIVITIES
    - People
    - Areas / Rooms
- **FIRE / HAZARD**
- **REGULATIONS**
- **NECESSARY PROVISION OF FIRE SAFETY SYSTEM**
- **COST BENEFIT ANALYSIS**
- **INSURANCE**
- **(FRA) FIRE RISK ASSESSMENT or (QRA) QUANTITATIVE/QUALITATIVE RISK ASSESSMENT**
The diagram above shows the relevant work topics in doing risk assessment and it's application which is a part of the whole package that is introduced within this development of the fire safety evaluation procedure. Risk assessment of the establishment were also undertaken indirectly by the survey in Step A and Delphi Group 1 questionnaire. In general, the fire hazards in Malaysian schools were found to be caused by:-

a) The occupants carelessness when dealing with naked fire sources such as candle lights and oil lamps.
b) The wide use of combustible materials for buildings structures and components.
c) Lack of maintenance for electrical wiring and also using unsafe electrical equipment.
d) Most of the fire safety equipment installed was not working or maintained i.e.: alarm bell, fire extinguishers and exit door.
e) Water pressure too low for hydrants.
f) Lack of budget and management in terms of fire safety.
g) Fire safety knowledge and training is inadequate amongst the occupants.

In order to overcome the problems, an evaluation on the fire safety requirements for the buildings involved must be undertaken. The process of creating the evaluation procedure requires a very serious decision making steps and a vast understanding of the related subjects such as the building regulations, occupancy responses and level of awareness and risk analysis, fire growth phenomenon, and the possible approach to carry out the evaluation task to solve the problems. Therefore, a comprehensive study of all the fire safety subjects above are needed to be able to understand the problems and overcome the fire problems using appropriate proper approaches.

The following questions were answered in the simplest way:-

a) What is to be evaluated?
- Fire safety requirements in Educational Establishment
- Fire safety in terms of adequacy and performance against standard requirements
- Existing standard of the building, occupancy and regulations for fire safety
- The existing standard building(s) plan
- The awareness of occupants on fire safety as part of contribution and performance

b) What scope of educational establishments involved?
- The residential secondary schools and local universities which are fully supported by the Malaysian Government.
- Age of the occupancy involved above 11 years old.
- Fire safety requirement by the Building Bye-law 1984.

c) What are the procedures?
- Achieving the educational policy for fire safety
- Achieving the objectives of the policy
- Using the tactics to achieve the objectives
- Ensuring or establishing the required components for the success of the tactics
- Ensuring and establishing the sub components in supporting the components

d) How to ensure the procedure is right?
- Look at the aim of the studies i.e.: Life Safety etc.
- Contribution of each and every part that created the problem(s)
- Contribution of each and every part that helped to reduce or eliminate the problem(s)
- Both the above are involving the balance through assessment of risk, safety components and the hazard.
- Performance expectations that individual or system can give to eliminate the problem(s).
- The acceptable safety level agreed

e) Who will be involved, directly and indirectly?
- Students, Teachers, Staff, Administrators, Wardens, Educational Officers Professionals with various interests.
- Fire Safety Engineers and Buildings Professionals.
Where will it be done?

- Research is based on Malaysian Educational System
- Research is carried out both in Malaysian and in the U.K
- The location of the research base is at the University of Edinburgh.

Chapter 7.0 and 8.0 are concerning on the formation of the check lists resulted from the fire risk assessment analysis which has been done with the information given throughout the previous chapters. The information given through the fire risk assessment on the relevant building, activities and its occupancies are needed to be able to evaluate the performance of fire safety.

10.4 Step C: The Acceptable Standard and Performance Level by Evaluation Check Lists and Experimental Analysis.

The main target is to achieve the objectives set for the Fire Safety Policy in the Educational Establishment particularly the fully residential secondary schools, where a satisfactory and acceptable level of fire safety within the occupied buildings or areas are obtained based on the regulatory requirements or standard. It also enabled trade-off to be undertaken for more practical solutions and cost-beneficial results.

Overall, the perception of people towards building performance and particularly the fire safety in a building varies. The perception of the layman or the “ordinary person” will be different to that of the building professional. The differences are not only amongst the hierarchy of the community but also within any one group. A datum is needed to overcome the huge gap of perception about building and fire safety. Fire accidents involving certain types of buildings can result in a serious loss impact to the owner, the local community, the nation and to the international community. In this case, an approach has been taken which is mainly based on the discussion and perceptions of the Delphi Group on the importance of fire safety and the loss impact caused by the accidents. Therefore, the Delphi Group acting on behalf of the overall community has carried out decision making exercises to develop the ranking system and values for the importance of the components of building performance, particularly the fire safety systems.
The values were given based on percentages contribution of each fire safety component. However, a Norm of fire safety component list for educational buildings and the check list was produced through the study of risk assessment, questionnaire, literature search and Delphi Group 1.

The fire safety components appraisal performance check list that has generally focused on the selected 14 fire safety NORMs in Chapter 7.0. Each one of the components is being provided with performance appraisal check list which help to determine it workability and performance during any situation through out the life of the building particularly fire emergency. These check list is acting as guidelines to maintain the safety and security of the schools and its occupancies. The
contributory values given by the evaluator at each end of the component appraisal is only the points referred to the fire safety component quantitative performance evaluation appraisal that will assist the authority or evaluator in making their own final decision on the safety of the building inhabited or designed or constructed. A comprehensive knowledge of fire safety and any other related services and occupants comfort is needed to be able to produce a good check list that is easy to be applied by an evaluator. The evaluator with his/her knowledge comes to a decision on the level of fire severity, safety and risk within the space which is of concern and is focused specifically towards the vulnerability and safety of the area against fire hazards which may result from the deficiency or overprotection of the components being assessed.

The four main objectives of the fire safety appraisal performance check lists are:-

i. The potential loss impact of certain areas has to be assessed in terms of their operational hours, maintainability under taken, continuity of the objectives such as the activity carried out, disturbance from within and surrounding activities or services and dependencies on others. This will help to achieve the reduction of risk and attain a significant level of safety that is required within areas of concern.

ii. Criticality is needed in observation, questions and thoughts which perhaps will ensure that the components are assessed thoroughly and to ensure the maximum output expected during an emergency. The questions set to build up the check list also have undergone a critical development stages so that a comprehensive coverage is shown in the end result of the check list formation.

iii. The context of the check list is for the school requirements in terms of fire safety which are based on the law, therefore the evaluators will be able to refer to only a specific document which is directly focused on schools or educational buildings without being involved with the confusion with the requirements of non educational buildings.

iv. Improvement or changes to be done to the extent of having the components and other building provisions such as the services, comfort, ergonomics, surface materials, source of ignition, fuel load and items at risk need to be established. The check list probably will assist in the discovery of the source of ignition, fuel load and disordered systems that cause the fire to ignite and level of severity to be reduced in an area of concerned. The improvement due to the
components installed should be maintained 100% safety performance based on the stages of fire growth where it is expected to contribute.

The 'Components Appraisal Performance Check List' is very useful for maintenance and auditing purposes of the fire safety components. It should be used after the points scheme check list contribution by each components has been done by the professionals. The changes in the level of fire safety components performance could result in some degree of risk, fire threat, vulnerability or even safety either decreased or increased within the space of a building. So by using the check list, the level of safety standard required can be determined to the level of each of the components. As a result, any improvement or maintenance work that needs to be done to maintain the required level of safety, can be achieved.

Another parallel evaluation scheme was also produced along with the component inspection check list. It is very useful to be used as the complete evaluation task for the set of fire safety components within an area or a building. It provides some evaluation points scheme that involve interaction between the fire safety components which do not exist within the inspection check list, particularly to achieve the objectives set for the fire safety policy in the residential school and the educational establishment in general. Both the points scheme and the check list can be combined to produced a mathematical or numerical evaluation scheme for the fire safety evaluation procedure of the educational establishment.

This part of evaluation approach can only be used effectively once the professional evaluation points scheme check list has been done in the process of development of the evaluation scheme. This part of check list is actually a step ahead of the professional check list using the points scheme which is elaborated in Chapter 8.0.

The production of the Building Performance Evaluation Points Scheme Check List 1 for the Educational Establishment has been undertaken with reference to the Hospital scheme. Consideration has been given to four major parts in order to produce the points scheme evaluation check list in this chapter. One is the selection of the panel members of the Delphi Group 2. Two, is the information needed for the design requirement of the check list 1 which involved the interaction of the inter-relation between the policy, objectives, tactics and components, the
questionnaire design and method to conduct the meetings using Delphi approach. Three, is the formation of the points scheme by matrix multiplication for their interaction relationships and the design of the evaluation check list 1. Four is the method of using the evaluation points scheme check list 1 to evaluate the building areas in a typical school in Malaysia.

In general, the evaluation points scheme check list 1 is easy to use by the experts or by the trained personnel that will be doing the evaluation assessment. Results of the evaluation can be used for further evaluation of the whole educational establishment in terms of its’ acceptability safety standard against fire. The overall results from evaluation of the areas will give the total level of safety for the blocks of building within the school. Each block can then be accumulated its’ contributions to safety to form the overall safety of the particular school involved with the survey. Therefore, the overall evaluation of fire safety acceptability standard for a school is obtained.

The fire safety component can be analysed for their performance. An example was taken to investigate the smoke or heat detectors performances for school buildings in Malaysia. The results from the experimental analysis assist in the making of a decision for the expert or evaluator in terms of smoke detector location referred to the degree of inclination of the roof from pitch to flat roof type, the level of floors comparing to the height of the detectors on the roof and also the size of compartmentation as it becomes bigger or smaller. The conclusion of the experimental work was further elaborated in paragraph 9.9.

The whole study of the smoke detector optimal location is to do with the investigation of one of the fire safety component in a great depth on how it is performing and giving the best result for it’s purpose. It is also a kind of performance evaluation that probably can be done for other fire safety components. Other future experimental work that can be incorporated with this model could be the ventilated compartment with openings on the compartment walls either by windows or doors. The experimental work can also be presented using a computer model or mathematical calculation as it only involved time, distance and speed of movement or the flow rates.
Further research on other fire safety components in terms of their performance in a particular building should be carried out in the future. The diagram above is to summarised the whole steps that has been undertaken to develop the fire safety evaluation procedure for the educational establishment in Malaysia.

One of the major contributions given into the study of fire safety evaluation from this research is the involvement of the building occupants through the survey using the questionnaire. Their responses were taken into consideration in the process of developing the whole fire safety evaluation procedure such as the rank order of importance and priority of the spaces and areas within which they are occupying in the establishment. Another new approach was introduced in dealing with the Delphi group that the meeting were set as an examination room where the questionnaire were given and collected while the meeting is taken in place. Furthermore, the involvement of the non building professionals in dealing with matters which normally engineers and other professionals related to buildings were taking part in the decision making and discussion of importance. This is very important to be considered as most buildings are not being used by only one particular group of people but entirely occupied by people of different backgrounds. And the focus of the built environment is normally for the betterment of the human needs. The importance of building types within the community development was also resulted from the studies of buildings. Fire safety relationship with other building components in general terms were undertaken and a ranked order of the priority were set. This probably will assist the administrative officer in dealing with the annual budget location for the building maintenance work particularly for fire safety.

The responses given by the respondent through questionnaire seems to enabling the authority to implement directly the importance of certain fire safety education and promoting more frequent training by the fire brigade officer or other safety consultant for the occupancy of the educational establishment. The fire safety system within a particular building not only can be evaluated in terms of their adequacy to maintain the acceptable safety standard of that particular area but also can be assessed in terms of their own performance by using both the Check List 1 and Check List 2 proposed in this study. The smoke /heat experimental work also assisted in assessing the required performance expected by the detection system according to the geometrical analysis of a building. Other contributions were such
as the study of loss impact of a building types, level of environment required for the
comfortability of the building occupant within their work place and self assessment
of the occupants environment through the design of questionnaire with aim to
educate the people in terms of fire safety requirements.

The Fire Safety Evaluation Procedure for Educational Establishment in Malaysia
can be listed as follows:-

A) The Fire Safety Policy for Educational Establishment
   i) The current and future problems that may caused by fire in educational
      establishment boundary.
   ii) The Regulations and Other Related Fire Safety Standard Requirements
   iii) The Occupancy, Areas, and Activities plus Buildings Structures and
        Materials
   iv) The Potential Problems
        (Fire, Flood, Explosion, Arsonism)
   v) The Potential Available Solutions
        (Occupants, Safety Systems, Services, Structures including Professionals.)
   vi) Set The Objectives to Achieve and Related Tactics and Components
   vii) Method to evaluate the levels of equilibrium between the safety provision
        and potential source of ignition.
        (Check list, Experimental Work, Points Scheme)
   viii) Acceptable or Not Acceptable by the standard set.

10.5 Future Research Work

The future research work that could possibly be carried out as a continuation of this
research findings are suggested in the following paragraphs:-

1. The use of Delphi group and it’s procedure has assisted in clarification of
few uncertainties during the study of this fire safety evaluation scheme for
educational establishment. However it’s applicability could also well be used for
any other future policy making studies which does not have an adequate statistical
data to support the argument or agreement and also studies that involve human
perceptions and appreciation. The professional judgment and perceptions studies are usually involving a lot of descriptive data that probably can be synthesised to obtain simple answers by applying the Delphi Group techniques.

2. The survey methodology undertaken is quite popular in assisting individuals doing social sciences and other related studies with a slight different approach. In order to handle questionnaires individually, several points suggested within the text of this thesis could be useful to follow particularly involving establishment which does enquire a lot of administrative and bureaucracy within organisation. However, one should do a careful study of the establishment and it's environment or people that he or she will be dealing with before any of the same recommendation or approach within this thesis is applied.

3. The data accumulated as a result of the survey search in this study seems to have few possible usage for further analysis, for example the study of human behaviour during emergency, probably useful for setting a fire safety training procedure and psychology in fire emergency, particularly involving the educational establishment occupancies. It also appears that a possible teaching method might be able to develope for fire safety and its curriculum within the educational establishment.

4. The findings from the Delphi Group 1 on the studies of loss impact and priority were seems to allow some flexibility in design requirement either for building services, architectures, fire safety engineers and administrators. It may also help other departments such as the planning and local development authorities, to carry out research in implementation of structured plan for community, based on fire safety perspective.

5. Referring to the check lists 1 and 2, on 'points scheme' and 'performance evaluation' for fire safety components of the educational buildings, both the check lists are available to provide some kind of guidelines in the study of evaluation for other similar group of buildings such as offices building, youth hostels, etc. The application however may need some alteration and careful research which probably require to make the check lists applicable for other buildings.
6. The points scheme given by the check list were contributed by the U.K professionals. In order to implement the 'Points Scheme Evaluation Check list' on the schools in Malaysia, another form of professional group need to be formed within the region which could assist with the contributions of the new values for the evaluation.

7. Other sophisticated tools may be used for further research on similar experimental work, such as the computer where individual could write a computer program which could upgrade the predicted result from the experiment. This might be possible to be done by taking into consideration the time and distance of the smoke movement and the sensitivity of the detection system. Both may improve significantly the reliability of the results for the optimal location of smoke detectors, based on the geometrical of the buildings.

Few suggestions to the continuation of using this evaluation procedure on educational establishment is that, the numerical assessment using the check list and perception assessment given by the Delphi Group 1 and 2 and questionnaire will have to combine in making it possible as a practical fire safety engineering evaluation scheme of a building. The ways to do it has been suggested as follows:-

1. Select a number of safety professional to do the evaluation according to their own experience and evaluate the level of safety or risk of the particular school building. May be they can use their judgement and observation which then could give a certain points for the total assessment, for example, 350 over 500.
2. Secondly, train a few evaluators that are going to use the evaluation check list to go around the similar school buildings and do the evaluation but this time using the check list. Then, calculate the outcome of the total points given by the evaluation check list.
3. After that, compare the two results and try to get an average guideline that will distinguish the average points which will then take as the acceptable level. The lower total points given by the prescribed line probably can still need to be taken action but not as urgent and probably time could be the constraint.

The development of the fire safety evaluation procedure, that has been constructed and proposed in this thesis has achieved it's final and complete stage in order to be applied for schools in Malaysia to measure their fire safety acceptable standard.