THE ASSESSMENT OF FIRE RISK RATING BASED ON UNIFORM BUILDING BY-LAW (UBBL) FOR BUILDINGS IN USM ENGINEERING CAMPUS

MUHAMMAD MUHAIMIN AZHAD BIN NOOR HADI

SCHOOL OF CIVIL ENGINEERING
UNIVERSITI SAINS MALAYSIA
2022

THE ASSESSMENT OF FIRE RISK
RATING BASED ON UNIFORM BUILDING BY-LAW (UBBL) FOR
BUILDINGS IN USM ENGINEERING CAMPUS

By

MUHAMMAD MUHAIMIN AZHAD BIN NOOR HADI

This dissertation is submitted to

UNIVERSITI SAINS MALAYSIA

As partial fulfillment of the requirement for the degree of

BACHELOR OF ENGINEERING (HONS.)

(CIVIL ENGINEERING)

School of Civil Engineering
Universiti Sains Malaysia

October 2022

Appendix A8

UNIVERSITI SAINS MALAYSIA

SCHOOL OF CIVIL ENGINEERING
ACADEMIC SESSION 2021/2022

FINAL YEAR PROJECT EAA492/6
DISSERTATION ENDORSEMENT FORM

Title: Mechanical Properties of Concrete with Different Types of Glass Waste as Cement Replacement Material

Name of Student: Muhammad Muhaimin Azhad Bin Noor Hadi

I hereby declare that all corrections and comments made by the supervisor(s)and examiner have been taken into consideration and rectified accordingly.

Signature:

Date: 7/08/2022

Approved by:

(Signature of Supervisor)

Name of Supervisor: DR. MUSTAFASANIE M. YUSSOF.

Date : 10/8/2022.

Approved by:

(Signature of Examiner)

Name of Examiner: Dr. Fadzli Mohamed Nazri

Date : 10 Aug 2022

ACKNOWLEDGEMENT

First and foremost, praises and thanks to Allah S.W.T for His showers of blessings throughout my difficulties and challengers to complete the final year project successfully.

I would like to express my gratitude to my respectful advisor Dr Mustafasanie M. Yussof, for the continuous support of my studies and research, mainly for the final year report dissertation. He sacrifices and keeps on showing his patience, motivation and immense knowledge regarding the flow of my project. His guidance helped me all the time researching and writing this complete dissertation of my project.

Besides my adviser, I'd like to thank all the professors who participated in the final year project, notably Dr. Noorhazlinda Abd Rahman, for giving me the essential knowledge and recommendations to accomplish my dissertation. Without help, my dissertation will be a mess. Other than that, thanks to Muhamad Azhar Zakaria from Pusat Pembangunan that provided fire hydrant and fire water tank plans. Never fail to appreciate the pleasant and helpful staffs, especially Mr. Mohd Fauzi Zulkfle and Mr. Abdullah Md Nanyan, who helped me throughout checking. My appreciation also extends to all my friends especially my friends Nadia Syahiera binti Salleh and Amir Syazwan bin Abu Bakar that always show their supports throughout the process of success. I felt very appreciated to have them by my sides to get through a hard time.

Last but not least, I would like to acknowledge with gratitude, the support and love of my family that give me a lot of space and time to complete this research without giving any pressure and always pray for my success.

ABSTRAK

Penilaian risiko kebakaran ialah pemeriksaan sistematik tentang perkara yang dalam aktiviti kerja dan tempat kerja anda menimbulkan bahaya kebakaran kepada manusia. Menjalankan penilaian risiko kebakaran di kemudahan adalah penting dan penting. Penilaian risiko kebakaran boleh membantu mengurangkan atau mengelakkan kebakaran, melindungi harta benda dan kakitangan, dan mengenal pasti dan mengawal bahaya tempat kerja. Biasanya penilaian risiko kebakaran dilakukan dengan menggunakan senarai semak dan memberikan keputusan kekurangan kriteria. Untuk menjadikan penilaian risiko kebakaran lebih cekap dan berfungsi, kadar pematuhan digunakan untuk membuat penilaian risiko kebakaran lebih cekap. Dalam kajian ini, penilaian risiko kebakaran akan dilakukan di bangunan tertentu di kampus Kejuruteraan USM iaitu Perpustakaan, Pusat Pengajian Kejuruteraan Awam, Makmal Kejuruteraan Awam, Pusat Pengajian Kejuruteraan Kimia, Pusat Pengajian Kejuruteraan Mekanikal, Pusat Pengajian Bahan dan Sumber Mineral, dan Asrama. SH5. Tujuan kajian ini adalah untuk membangunkan skala wajaran bagi kriteria pasif dan aktif UBBL dan menganalisis kadar pematuhan bangunan terpilih di Kampus Kejuruteraan. Wajaran yang telah digunakan projek ini adalah dengan merujuk kajian terdahulu yang semata-mata untuk sistem perlindungan aktif dan pasif. Kadar pematuhan untuk sistem perlindungan aktif dan pasif telah dicapai untuk setiap bangunan yang dipilih. Kadar pematuhan terbesar untuk aktif dan pasif ialah Perpustakaan yang sepadan dengan 6.5877 dan 2.172. Manakala, kadar pematuhan terendah bagi aktif dan pasif ialah Pusat Pengajian Kejuruteraan Mekanikal bagi sistem perlindungan pasif dan Makmal Awam iaitu 4.334 dan 1.8072 masing-masing. Oleh itu, kadar pematuhan boleh membantu membandingkan penilaian risiko kebakaran dan boleh mengetahui faktor keselamatan.

ABSTRACT

A fire risk assessment is a systematic examination of work activities and workplace poses a fire hazard to humans. A fire risk assessment can assist reduce or avoiding fires, safeguarding property and personnel, and identifying and controlling workplace dangers. Commonly fire risk assessment is done by using a checklist and giving the result of lacking criteria. To make fire risk assessment more efficient and functional, the compliance rate is being used to make a fire risk assessment more efficient. The purpose of this study is to develop the weightage scale for the passive and active criteria of UBBL and to analyse the compliance rate of the selected buildings in the Engineering Campus. In this study, fire risk assessment will be done in 7 buildings of the USM Engineering campus which are the Library, School of Civil Engineering, Laboratory Civil Engineering, School of Chemical Engineering, School of Mechanical Engineering, School of Material and Mineral Resources, and Hostel SH5. The weightage that has been used in this project is by referring earlier study which are solely for active and passive protection systems and the highest score weightage for active and passive are 7 and 3 respectively. The compliance rate for active and passive protection systems was achieved for every building that has been chosen. The greatest compliance rate for active and passive is Library which is 6.5877 and 2.172 correspondingly due to all the criteria has the highest score. Meanwhile, the lowest compliance rate for passive was the School of Mechanical Engineering which is 4.334 due to have highest distance for travel distance. The lowest compliance rate for active was Laboratory Civil which is 1.8072 due to the hose reel is not comply with the UBBL. Therefore, the compliance rate may help compared the fire risk assessment and can know the safety factor.

TABLE OF CONTENTS

ACKNOWLEDGEMENT iv

ABSTRAK iii

ABSTRACT iv

TABLE OF CONTENTS v

LIST OF TABLES ix

LIST OF FIGURES x

CHAPTER 1 INTRODUCTION 1

1.1 Background of research 1

1.2 Problem Statement 3

1.3 Objectives 4

1.4 Scope of works 5

1.5 Dissertation Outline 5

CHAPTER 2 LITERATURE REVIEW 7

2.1 Overview 7

2.2 Background of UBBL 7

2.3 Fire Risk Assessment Based On UBBL 9

2.4 Passive Protection System 15

2.5 Active Protection System 17

2.6 Fire Management 19

2.7 Building Characteristic 19

2.8 Summary 20

CHAPTER 3 METHODOLOGY 21

3.1 Overview 21

3.2 Selected Building 22

3.3 The Weightage Scale For The Passive And Active Criteria Of UBBL 23

3.4 Passive Protection System 23

3.4.1 Compartmentation 25

3.4.2 Egress/ Evacuation Route 27

3.4.3 Corridor Width 28

3.4.4 Number of Exit 29

3.4.5 Maximum Travel Distance 30

3.4.6 Exit Signages 31

3.4.7 Site Accessibility 33

3.5 Active Protection System 35

3.5.1 Detection and Alarm 36

3.5.2 Automatic Suppression System 38

3.5.3 Fire Hydrant 39

3.5.4 Portable Fire Extinguisher 40

3.3.5 Emergency Lighting 41

3.3.6 Hose Reel and Standpipe 42

3.3.7 Communication 43

3.6 Evaluation the compliance rate of the selected buildings in the Engineering Campus 44
CHAPTER 4 RESULT AND DISCUSSION 46
4.1 Overview 46
4.2 The Compliance Rate Of The Selected Buildings In The Engineering Campus 46
4.3 Active Protection System 47
4.3.1 Detection and Alarm 48
4.3.2 Automatic Suppression System 50
4.3.3 Fire Hydrant 51
4.3.4 Portable Fire Extinguisher 52
4.3.5 Emergency Light 53
4.3.6 Hose Reel and Standpipe 54
4.3.7 Communication 56
4.4 Passive Protection System 57
4.4.1 Compartmentation 58
4.4.3 Corridor Width 61
4.4.4 Number of Exit 63
4.4.5 Maximum Travel Distance 65
4.4.6 Exit Signage 67
4.4.7 Site Accessibility 69
CHAPTER 5 CONCLUSION AND FUTURE RECOMMENDATIONS 71

5.1 Conclusion 71

5.2 Future Recommendations 72

APPENDIX A FIRE HYDRANT LOCATION 75

APPENDIX B PASSIVE PROTECTION SYSTEM FORM 76

APPENDIX C ACTIVE PROTECTION SYSTEM FORM 80

LIST OF TABLES

Table 2.1: Definition of UBBL 1984 sections ... 8

Table 3.1: Score Guideline for Compartmentation ... 26

Table 3.2: Score Guideline for Egress/ Evacuation Route ... 28

Table 3.3: Score Guideline for Corridor Width ... 29

Table 3.4: Score Guideline for Number of Exit ... 30

Table 3.5: Score Guideline for Maximum Travel Distance ... 30

Table 3.6: Score Guideline for Exit Signage ... 32

Table 3.7: Score Guideline for Site Accessibility ... 33

Table 3.8: Score Guideline for Detection and Alarm ... 37

Table 3.9: Score Guideline for Automatic Suppression System ... 38

Table 3.10: Score Guideline for Fire Hydrant ... 39

Table 3.11: Score Guideline for Portable Fire Extinguisher ... 40

Table 3.12: Score Guideline for Emergency Lighting ... 41

Table 3.13: Score Guideline for Hose Reel and Standpipe ... 42

Table 3.14: Score Guideline for Communication ... 43

LIST OF FIGURES

Figure 2.1: 10 Criteria of Fire Risk Assessment (Ramachandran, 1999) 11

Figure 2.2: Relationship of Fire Safety and Fire Risk (Ibrahim et al., 2011) 14

Figure 2.3: Passive Protection System Form (Ibrahim et al., 2011) 14

Figure 2.4: Weightages of main criteria and attributes (Ibrahim et al., 2011)............... 15

Figure 3.1: Research Methodology Flow Chart.. 22

Figure 3.2: Weightage For Passive Protection System.. 24

Figure 3.3: Passive Protection System Form 25

Figure 3.4: Law 162 of UBBL 1984... 26

Figure 3.5: Law 178 of UBBL 1984... 28

Figure 3.6: Law 181 of UBBL 1984... 29

Figure 3.7: Law 173 of UBBL 1984... 30

Figure 3.8: Law 188 of UBBL 1984... 30

Figure 3.9: Law 172 of UBBL 1984... 32

Figure 3.10: Proportion of the building 33

Figure 3.11: Weightage For Active Protection System 35

Figure 3.12: Active Protection System Form 36

Figure 3.13: Law 237 of UBBL 1984... 37

Figure 3.14: Law 236 of UBBL 1984... 38

Figure 3.15: Law 225 of UBBL 1984... 39

Figure 3.16: Law 227 of UBBL 1984... 40

Figure 3.17: Calculation for Attributes Score.. 45

Figure 3.18: Calculation for Final Score For Criteria.. 45

Figure 3.19 Example of Calculation For Attribute Score.. 45

Figure 4.1: Graph Compliance Rate of Active Protection System 48

Figure 4.2: Attributes Score of Detection and Alarm 49

Figure 4.3: Existing Detection and Alarm in Building 49

Figure 4.4: Bar Chart of Attribute Score for Automatic Suppression System............... 50

Figure 4.5: Oven in School of Civil Engineering and Flammable Chemical in School of Chemical Engineering 51

Figure 4.6: Graph Attributes Score for Fire Hydrant.. 51

Figure 4.7: Fire Hydrant Location in School of Chemical Engineering........................ 52

Figure 4.8: Bar Chart Attributes Score for Fire Extinguisher....................................... 53

Figure 4.9: Bar Chart Attribute Score for Emergency Light 54

Figure 4.10: Existing Emergency Light.. 54

Figure 4.11: Bar Chart Attribute Score for Hose Reel System..................................... 55

Figure 4.12: Hose Reel Condition in Laboratory Civil... 56

Figure 4.13: Bar Chart Attribute Score for Communication System............................ 57

Figure 4.14: Graph Compliance Rate for Passive Protection System 58

Figure 4.15: Bar Chart Attribute Score for Compartmentation 59

Figure 4.16: FRP door at Opening Structures... 60

Figure 4.17: Bar Chart Attribute Score for Egress/ Evacuation Route.......................... 61

Figure 4.18: No FRP Door at Evacuation Route 61

Figure 4.19: Bar Chart Attribute Score for Corridor Width 62

Figure 4.20: Corridor Width that Obstructed with Object.. 63

Figure 4.21: Bar Chart Attribute Score for Number of Exit 64

Figure 4.22: Width of Exits at Library... 64

Figure 4.23: Width of Exits at Hostel SH5 65

Figure 4.24: Bar Chart Attribute Score for Maximum Travel Distance 66

Figure 4.25: Roll Meter.. 66

Figure 4.26: Bar Chart Attribute Score for Exit Signage 67

Figure 4.27: Existing Exit Signage 69

Figure 4.28: Blocked Exit Signage 69

Figure 4.29: Bar Chart Attribute Score for Exit Signage 70

CHAPTER 1

INTRODUCTION

1.1 Background of research

A building audit evaluates a structure to determine its suitability for a particular purpose. If specific components match the required standards, an audit might also recommend corrective measures to make the structure safe or inhabitable again. The audit is based on national norms and standards, such as the Uniform Building By-Laws (UBBL) and the Street Drainage and Building Act of 1974. They must inspect for structural difficulties, situations conducive to structural damage, faults in secondary and finishing elements, unfinished construction, and safety hazards, among other things. Academic buildings on the USM Engineering Campus are crucial for safeguarding the academic environment for students and users. Budget allocation is typically determined by a fire risk assessment that is interpreted based on the perception stakeholders' perceptions has been renovated according to UBBL fire regulations.

Based on UBBL, there are numerous critical criteria for fire risk. Ibrahim et al., (2011) identifies four significant fire risk criteria: passive protection system, active protection system, building characteristic, and fire management. Ismawati & Mariati, (2013) states that passive and active protection systems are two essential factors for fire risk. Fire risk assessment requires an evaluation of the building's active and passive fire safety measures by regulations and standards, such as the Uniform Building By-Law (UBBL) By-Law Malaysian Standard (MS, and British Standard (BS) (Akashah et al., 2017).

A passive fire prevention system is a collection of components or systems in a building or structure that slow or impedes the fire or smoke without the need for system activation or movement. Passive systems include floor, ceiling, roof assemblies, fire doors, windows, fire-resistant coatings, and various fire and smoke control assemblies. Active Fire Protection (AFP) is a collection of systems that require action or motion effectively during a fire. Actions may be manual, like a fire extinguisher, or automatic, like a sprinkler, but they all require action. AFP includes fire/smoke alarm systems, sprinkler systems, and extinguishers, and structure, fire/smoke alarm systems detect the presence of fire and/or smoke. Sprinkler systems are employed to slow the fire's spread. Firefighters and fire extinguishers are utilised to extinguish the fire entirely.

Active fire protection was installed within a building or premises to provide fire prevention and fire control services. These fire protection systems require some number of actions such as the power supply and manually operated to function efficiently and effectively in a fire. When fire and smoke detected by a fire or smoke alarm, it will start to operate and function to alert the occupants of the building. The fire extinguishers and a sprinkler system helped to slow down the growth of the fire until fire authorities have the chance to get there. Therefore, portable fire extinguishers, automatic sprinkler system, fire alarm and detection system, hose reel were a typical example of active fire protection for a building.

In order to determine the fire risks in high-rise residential structures, this method is utilised to detect the fire dangers. Data is gathered through observation. A scale from 0 to 10 is typically used to rate an assessor's observations. AHP is a multi-criteria decision-making method that produces analyst data from calculations using Microsoft Excel as a substitute supportive fire risk ranking (Ibrahim et al., 2011). Each building on the USM Engineering Campus will be observed, and a score will be assigned based on the state of the facility. A professional engineer licenced under the Registration of Engineers Act 1967 must inspect any buildings that are five floors or more and older than ten years according to Section 85A of the Street, Drainage and Building Act 1994 of the Law of Malaysia (Fui, 2021). The Act also specifies that the building owner is in charge of carrying out the periodic examination following receipt of a notice from the local government.

Therefore, the building's fire requirements must meet with Malaysia's Uniform Building By-Law (UBBL) of 1984 and offer all safety elements. This report covers the results of investigations of passive and active fire protection systems installed in buildings on the USM Engineering campus in accordance with UBBL 1984 fire safety regulations and the level of occupant knowledge regarding the installations.

1.2 Problem Statement

The majority of the structures on the USM Engineering Campus in Nibong Tebal, Pulau Pinang, were completed in the 1990s. The campus was formed in 2001. All of the buildings were erected in compliance with UBBL 1984, although they have been regularly altered or restored since then. Is the structure fire-safe and has it been reconstructed in accordance with the UBBL 1984. The structure is in jeopardy if fire safety has not been established in accordance with the UBBL. In addition to causing deadly and nonfatal injuries to building occupants, fires directly damage structures and their contents. Some fires result in indirect/consequential losses, such as lost output, profits, employment, and exports, however these losses do not contribute significantly to the national total fire loss.

The purpose of a fire risk assessment is to identify two fundamental factors: fire risks and fire hazards. In the case of fire dangers, the assessor must calculate the likelihood of a fire, its severity, and the amount of damage incurred. The fire risk assessment method nowadays is using the checklist method which is not efficient and is difficult to comply with UBBL 1984. The compliance rate can analyse the weakness of fire safety for each building and can detect the lack of the active or passive protection system.

The standard method does not have a rating system during fire risk assessment and maybe the building had some renovation at certain that complies with UBBL 1984 which is it cannot know the deficiency active or passive. Therefore, the main contribution for this research is to improve the fire risk assessment method which is the checklist method with the compliance rate. This research aims to examine the evaluation of weightage fire risk ratings for structures based on Universal Building By Laws (UBBL). In order to determine the weightage of a building's fire risk rating, a comparison is performed to determine the most important factors for fire risk assessment. Determine then the weighting scale for the passive and active UBBL criterion. The findings were determined by multiplying the building's inspection score by the weighting factor. By multiplying the score by the weight, the compliance rate of the selected buildings on the USM Engineering Campus with respect to UBBL is determined.

1.3 Objectives

The objective of this study are:

- To determine the weightage scale for the passive and active criteria of UBBL
- To evaluate the compliance rate of the selected buildings in the Engineering Campus, USM with respect to UBBL.

1.4 Scope of works

This study begins with to make analysis about fire risk assessment to the existing building at USM Engineering Campus. The fire risk assessment is based on the requirement that set by UBBL 1984. The fire assessment for this research in only focus on active and passive protection system. To achieve the objectives above, the scope of the study is as follows the study was focused on the current building of fire risk based on UBBL. Meanwhile, for building that need to check the compartmentation are neglected since it is complicated to make the checking. In addition, the detection and alarm are being checking by referring the fire alarm control and the testing method are complicated to obtain due a lot of approval are needed. Based on results from checking, we are able to know the condition of the building and suggest the improvement with reference to UBBL.

1.5 Dissertation Outline

The dissertation for this project comprises of 5 chapters which are Introduction, Literature Review, Methodology, Results and Discussion, and Conclusion. Chapter 1 of this dissertation provide a glance on the background of study, problem statements, objectives, scope of work and the dissertation outline for overall chapter.

Besides, chapter 2 relates the findings and conclusions made by past research associated to the components are reviewed. An summary of past researchers' ways of calculate weightage fire risk ratings for structures based on universal building codes (UBBL). Furthermore, this chapter provides the majority of the relevant criteria in recent fire risk assessment-related research that have concentrated on this study.

Moreover, Chapter 3 explains about the methodology and procedures that will be conducted for this study. All of the modification of sample preparation are listed to avoid false information happened during checking sessions. Each of the steps are explained in details with the additional information of data collection, analysis process and presentation.

Last but not least, Chapter 4 examined in depth the results gained from the conducted checks. The discussion is offered as a table, graph, and an explanation of whether or not the desired results were obtained. The collected results must correspond to the research outcomes that demonstrate the success of this investigation.

Chapter 5 finishes the overall accomplishment that satisfied this project's aims. Recommendations and suggestions are provided as a resource for any individual or group interested in enhancing this study.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This research is divided into numerous components in this chapter, and the findings and conclusions created by past research connected to the components are discussed. An summary of previous researchers' techniques to calculating weightage fire risk ratings for structures based on universal building codes (UBBL). Furthermore, this chapter contains the majority of the significant criteria in recent fire risk assessment-related studies that have focused on this study.

2.2 Background of UBBL

In Malaysia, the Uniform Building By-Laws (UBBL) 1984 adopted under the Street Drainage and Building Act 1974 require all new buildings to submit designs for approval prior to construction by a principle submitting person (PSP), such as a Professional Architect and Professional Engineer. The UBBL 1984 specifies the structural requirements of a building in terms of the design and specifications of materials, loads, foundation, and superstructure, which control the design, specifications, and construction of walls, floors, and building structures. Additionally, the UBBL 1984 set construction and fire criteria for buildings.

According to Hisham, (2011), one of the aims of the Uniform Building By-Laws, (UBBL) 1984 was to provide standardised building laws applicable to all Local Authorities and building professionals throughout Malaysia. In addition, UBBL 1984 simplified the legal duties for buildings by defining the Principal Submitting Persons with precision. In addition, it specifies the architectural, structural, health & safety, fire protection, and construction criteria for buildings with unambiguous references to the authorised standards. In UBBL 1984, there are nine main sections with 258 legislations. Table 2.1 displays the UBBL 1984 defining sections. There are 10 schedules indicated in the appendix, however only the ninth and tenth schedules will be utilised in this study. In the Ninth Schedule, the requirements for compartment limits and minimum fire resistance durations for structural elements are specified. The Tenth Schedule lists the standards for every type of building's fire extinguishing alarm system and emergency lights.

Table 2.1: Definition of UBBL 1984 sections

PARTS	DEFINE
PART I	*Definitions and interpretations used in the by-laws [By-Laws Sections 1 - 2],*
PART II	*The procedures for submitting plans to the Local Authorities for their approval for permanent and temporary buildings, advertisements and perimeter hoardings [By-Laws Sections 3 - 29],*
PART III	*The required space [dimensions], light and ventilation to be provided in buildings [By-Laws Sections 30 - 47],*
PART IV	*The required temporary works during construction [By-Laws Sections 48 - 52],*
PART V	*Structural requirements and considerations e.g. dead, superimposed and dynamic loads and, structural materials and elements [By-Laws Sections 53 - 80],*
PART VI	*Constructional requirements e.g. site preparation, constructional materials, method of construction and, architectural and related Structural and M&E requirements [By-Laws Sections 81 - 132],*
PART VII	*Passive fire protection requirements [By-Laws Sections 133 - 224]*
PART VIII	*Active fire protection requirements [By-Laws Sections 225 - 253]*
PART IX	*Miscellaneous definitions and references and, the procedures for reporting on building failures [By-Laws Sections 254 - 258].*

2.3 Fire Risk Assessment Based On UBBL

A Fire Risk Assessment (FRA) is an evaluation of a structure to determine its fire risk and, if necessary, give recommendations to make the facility safer. It is a methodical examination of your workplace to identify potential fire hazards and assess the level of risk associated with such hazards. The objective is to remove or reduce these threats to an acceptable level. Watts & Kaplan, (2001) contended that it is essential to analyse fire risk in buildings in order to determine the fire safety level's repercussions. To ensure the building's safety and to select the most appropriate corrective measures, it is necessary to conduct a thorough and exhaustive fire risk assessment. FRA is a crucial component of fire risk management. Not only does it aid in comprehending the fire threats existing in a building, but it also enables remedial measures to be implemented (Akashah et al., 2017).

Using a FRA methodology, Akashah et al., (2017) establish the fire risk status of low-cost high-rise residential buildings in Kuala Lumpur. This study is part of a larger effort to establish a Fire Risk Indexing (FRI) technique for affordable high-rise residential buildings in Kuala Lumpur. Using a 10-item FRA checklist, on-site fire audits were conducted at three (3) low-cost high-rise residential complexes in the city of Pantai at Kuala Lumpur.

A FRA is one way for establishing the fire risk status of a building. The Fire Regulation Authority (FRA) requires a building to undergo a fire safety audit, which involves evaluating the presence and operation of active and passive fire protection systems, typically in accordance with relevant guidelines and standards such as the Uniform Building By-Laws (UBBL) 1984, the Malaysian Standard (MS), and the British Standard (BS) (BS). According to the BS8800:1996 Guide to Occupational Health and Safety Management Systems, FRA is the process of evaluating the severity of a fire risk and determining whether the risk is acceptable or not. FRA refers to the examination of potential fire threats to people and property, as well as the capacity to contain and escape a fire without suffering injury (Akashah et al., 2017). It entails evaluating the likelihood of a fire occurring (hazard) and the consequences of a fire occurring. Figure 2.1 depicts the ten criteria for the fire risk assessment that are considered. They have performed their verification by assigning a score for probability multiplied by impact. The rating was derived from the Department for Communities and Local Government (2006); NFPA (2016); (Ramachandran, 1999).

All ten FRA criteria were found to have various concerns, ranging from the existence of multiple ignition and fuel sources to inadequate or vandalised firefighting equipment and a lack of instruction on fire risk and safety for residents. Further investigation revealed that the observed buildings posed a "high" fire risk. It was determined that immediate intervention steps are required to improve the fire safety credentials of the observed case study structures. Reconsidering the design arrangement of rooms, enhancing active and passive fire safety protection measures, and training occupants to increase their awareness of fire safety are among the recommendations.

Figure 2.1: 10 Criteria of Fire Risk Assessment (Ramachandran, 1999)

Ismawati & Mariati, (2013) evaluated passive and active fire protection systems installed in buildings in accordance with UBBL 1984 fire safety regulations and the level of knowledge of building inhabitants regarding the installations. The fire prevention system in student housing was reviewed. The environment of student housing should be aesthetically pleasing, conducive to learning, and most importantly, safe. Compartments and fire doors were inspected as part of the passive fire protection system. As part of the active fire protection system, the sprinkler system, hose reel, break glass, heat detectors, some detectors, fire panel, portable fire extinguisher, fire lift, exit signage, and emergency lighting were inspected. They employed a questionnaire to measure respondents' degree of knowledge about fire protection systems. The examination was undertaken on two buildings: Tekun, which was constructed after 1984, and Aman Damai, which was constructed in 1969.

Consequently, the building in the case study has been outfitted with adequate fire protection equipment and meets the standards of UBBL 1984; nevertheless, the fire protection systems installed in the new and old buildings are distinct. The design of the structures appears to influence the given system. A study of Aman Damai and Tekun student housing revealed numerous significant discrepancies in the active fire protection systems, particularly the equipment. Due to the form of the building, Tekun required a variety of equipment. Tekun is a new building developed after the UBBL 1984 building code was implemented. Aman Damai is an older structure that was only brought into compliance with the UBBL when it was equipped with an active fire protection system. Regarding fire system knowledge, the results indicate that the majority of respondents lack fire safety system knowledge, which is risky for the students.

Tharmarajan, (2007) has identified the components of fire safety management that have an impact on the fire safety of high-rise building occupants. Even when high-rise structures are equipped with the most advanced fire safety measures, the safety of the building's occupants remains questionable. Fire outbreaks are caused by human reasons such as carelessness, ignorance, or a lack of fire safety awareness. Professional interviews are done with the relevant individuals involved in the day-to-day operations of high-rise structures in order to gather their comments. On the basis of the literature research and interview information, a questionnaire is constructed, and field data collection is undertaken to get the required information. The data is then analysed, and conclusions are drawn.

Consequently, the three most essential aspects of fire safety management are the education and training of high-rise building occupants in fire safety, the implementation of fire and evacuation drill procedures, and the provision of clear signage indicating exit routes and the location of fire safety equipment. Tharmarajan, (2007) suggests that the three best ways to improve the fire safety of high-rise building occupants are to ensure that flammable materials are stored in a secure location, to conduct more educational and training programmes for building occupants, and to ensure that there is clear or "glow in the dark" v signage indicating exit routes and the location of fire safety equipment.

A Fire Safety Ranking System (EB-FSRS) is proposed by (Chow, 2002) for evaluating the fire safety provisions in existing high-rise non-residential buildings in Hong Kong. The architectural features, interior details, and fire safety measures of 37 ancient high-rise buildings were analysed. The objective is to determine how far the fire safety measures in these older structures deviate from what is required by modern laws. During the transition period, proper fire safety management can be created based on the scores. Initially, local fire laws were reviewed to identify which elements should be included and how they should be weighted. In the EB-FSRS, three sets of attributes were proposed based on the outcomes of the review. The passive building construction, active fire protection measures (installation of fire services), and critical risk factors are all in compliance with local fire safety laws. Consequently, the new EB-FSRS is compared to the NFPA-FSES (old technique) for commercial buildings. The concepts underlying the two systems are similar, but their purposes are distinct; the EB-FSES is designed to assist occupants in developing fire safety management plans. This differs from NFPA-emphasis FSES's on obtaining an equivalency design.

Ibrahim et al., (2011) had examines s the criteria and attributes for assessing fire risks in buildings. The Analytical Hierarchy Process (AHP) was used to construct a survey questionnaire based on the established criteria and attributes of fire threats for heritage buildings in Malaysia. Consultants, Fire Rescue Department Malaysia (FRDM) workers, maintenance specialists, and insurance professionals were given the survey questionnaire. From the interviews with expert panels, a set of weightings for each criterion and its corresponding features was derived using the expert choice software. As risk is a direct opposite of safety, the risk index is measured by measuring the safety and converting it to the direct opposite score (Figure 2.2) (Ibrahim et al., 2011). The observation of an assessor was recorded and graded based on 1 to 10 scales which is the highest the score, the highest the fire safety. An objective worksheet in the form of condition survey checklist was developed as shown in Figure 2.2. The weightage for criteria and attributes is as per Figure 2.3 below that produced from the research. The final score of each criteria will been produce by multiply total attributes score for the criteria with criteria weightage. As a result, total fire safety score (total final score from criteria 1 to criteria 4) is 5.40 which it in the mid-range.

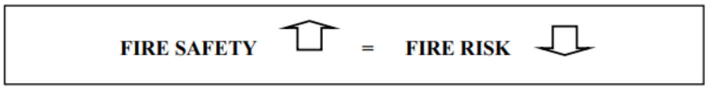

Figure 2.2: Relationship of Fire Safety and Fire Risk (Ibrahim et al., 2011)

CONDITION SURVEY SHECKLIST

THE RESIDENCY, KUALA LUMPUR

CRITERIA 1 : PASSIVE PROTECTION SYSTEM

Attributes	Assessment Items	Observation	Assessment Grade
Compartmentation	1.Check fire rated of wall/door & compliancy with UBBL		
	2.Chech hazard segregation		
Egrees/ evacuation route	1.Alarm / suppression system installed along the evacuation route		
	2.Protection along the evacuation route		
	Clause 188 UBBL : max, travel distance to place of assembly for sprinkled route 601m and for un-sprinkled route 45m		
	Clause 178 UBBL : Route to final exit must be protected and separated		
Corridor Width	1.Check corridor width according to UBBL requirement		
	Clause 181 UBBL :...no individual access shall be less than 700mm		
Number of Exit	1.Check number of final Exit available		
	2.Check width of exit		
	Capacity at least 100 person/exit for horizontal and 75 person/exit for staircase width of exit to be at least 500mm		
Maximum Travel Distance	1.Check maximum travel distance whether it is in accordance with UBBL		
	Clause 188 UBBL : Max, travel distance to place of assembly from any point to exit for sprinkled route 60m and for un-sprinkled route 45m		
Exit Signages	1.Number of exit signage		
	2.Sustainability of signage lacation		
	3.Specification of signage		
	Clause 172 UBBL : shall be marked, strategically located, signage according to specification given, illuminated at all time		
Site Accessibility	1.Check accessibility of site according to UBBL		
	2.How many side is accessible by BOMBA		

Figure 2.3: Passive Protection System Form (Ibrahim et al., 2011)

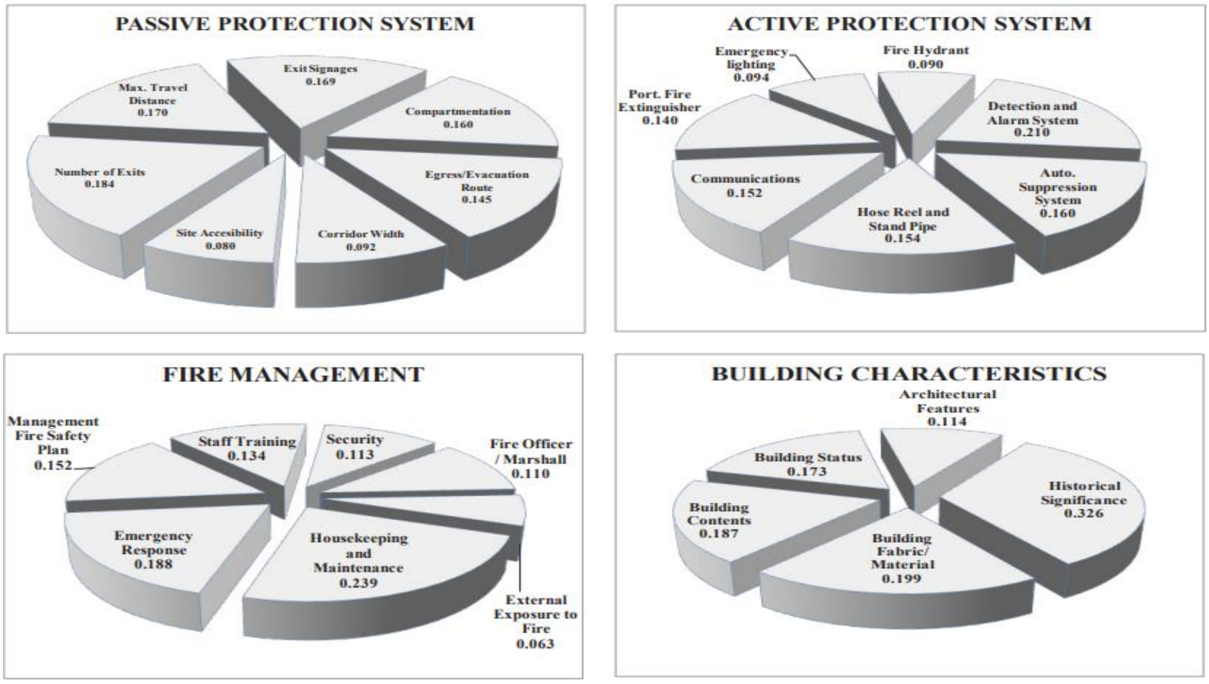

Figure 2.4: Weightages of main criteria and attributes (Ibrahim et al., 2011)

There are several research on fire risk assessment have been conducted, and numerous approaches/frameworks have been established. As seen in Figure 2.4, the research conducted by (Ibrahim et al., 2011) revealed the most exhaustive parts of the fire risk framework, which highlighted the essential criteria for the fire risk assessment. Therefore, passive protection system, active protection system, fire management, and building characteristics are the four most essential parameters for fire risk assessment.

2.4 Passive Protection System

A passive fire protection system is comprised of components or systems of a building or structure that slow or hinder the spread of fire or smoke without activating the system and typically without movement. Passive fire protection systems are designed to confine a fire to the compartment of fire origin, slow a fire's spread from the compartment of fire origin, and prevent the spread of fire through penetrations in fire-rated assemblies, such as holes in fire walls through which plumbing pipes or electrical cables pass.

Chow (2002) has stated that the important thing for passive protection system which are building height, evacuation route, width of staircase, smoke doors and fire resistance construction.

Hou, (2018) had identify the condition of fire safety aspect and propose the measures to enhance the fire safety aspect for active and passive in the high-rise residential buildings. Mixed methodologies with quantitative and qualitative methods adopted in the research. observation and questionnaire selected as the data collection method. The raw data was collected from five high-rise residential buildings. observation and questionnaire selected as the data collection method. The raw data was collected from five high-rise residential buildings. The building should make sure a comprehensive fire safety plan while building management and occupants cooperate to maintain a safer accommodation.

Ismawati & Mariati (2013) has studied research of an assessment of fire protection system in student accommodation and they stated the important thing of passive protection system. Passive fire protection system at student accommodation are compartment and fire doors.

Faizul & Muhammad (2018) has studied research of compartmentation and stated that the spaces in the building are split into smaller compartments for fire safety management reasons to prevent the spread of fire, control the movement of smoke, optimize escape routes during the fire and also accommodate varied activities (Purpose Group). This is done to enable each compartment to have its own fire defence systems. In addition, fire doors of the required Fire Resistance Period (FRP) shall be installed; openings in the compartment and separating walls, such as in hotel guest rooms, and AHU rooms. Openings in protecting constructions, such as protected staircases, protected lobbies, and firefighting access lobbies. Openings in partitions enclosing a protected corridor or lobby.

Kara (2014) conducted research on the exit signage which is the evolution of exit sign technology over the past few decades is a tale of new technologies that have drastically decreased their energy consumption. In fact, the most prevalent exit signs offered now, those with LED lights, utilise as low as two watts of energy, which is one-twentieth the amount of energy used by earlier incandescent models. Other that, some modern exit signs utilise no electricity at all.

Ibrahim et al., (2011) conducted research on the creation of a fire risk assessment technique for historic structures. They identified four critical parameters for the fire risk assessment: passive protection, active protection, fire management, and building characteristics. The compartmentation, evacuation route, corridor width, number of exits, maximum travel distance, exit signs, and site accessibility are some of the passive protective system requirements that have been evaluated.

2.5 Active Protection System

A system of active fire protection is a vital component of fire protection. In contrast to passive fire prevention, an active protection system is defined by products and/or systems that require motion and response in order to function. A system of active fire protection implies that action is being taken. This procedure may be manual, requiring the participation of a person or persons, or it may be automatic, deploying upon the detection of fire, smoke, or heat. Active systems are primarily intended to fight the fire instantly and aid in its extinguishment. The fire department will utilise an example of an active fire suppression system once they arrive. In the event of a fire, active systems, such as smoke detectors and fire extinguishers, are present in the majority of buildings.

Active fire protection systems are often designed with considerations such as the number of occupants and the size of the building in consideration.

Chow (2002) has stated that active protection system in the research are Fire hydrant/hose reel system, fire alarm system, fire detection system, sprinkler system, fire extinguishers, smoke control system, emergency lighting and exit signs.

Past research about fire risk assessment has investigate for active protection system which are sprinkler system, hose reel, break glass, heat detectors, some detectors, fire panel, portable fire extinguisher, fire lift, exit signage, and emergency lighting (Ismawati & Mariati, 2013).

Azmi et al., (2009) has determine that the important thing for fire extinguisher which is fire extinguishers must be placed in a conspicuous location where they are easily accessible and instantly available in the case of a fire. Ideally, they should be situated along normal travel routes, including exits from a given location. The fire extinguisher should be equipped with two units per building/floor, a maximum travel distance of 50 to 75 feet, and one unit for special hazard regions.

Maksimović & Milošević, (2016) conducted research on smoke detector which is the proposed arrangement is suitable because the distances between the most distant point and the projection of the nearest detector are smaller than the maximum distances (7,5 m). Otherwise, the number of detectors and the density of coverage must be increased.

According to UBBL, (1984) Law 255, each structure must have at least one fire hydrant positioned within 91.5 metres of the closest point of fire brigade access. Depending on the size and location of the structure and the availability of access for fire apparatus, the fire authority may demand the installation of extra fire hydrants. If there is no hydrant within a 45-meter radius of a new building, the developer must install one

(Law, 2014). The location of fire hydrant in USM Engineering campus can be refer at **Appendix A.**

According to UBBL, (1984) Law 226A, hose reel systems must be built and installed in compliance with MS 1489, and the minimum amount of water storage necessary for hose reel systems is 2275 litres for the first hose reel. Each extra hose reel costs 1137.50 litres, with a cap of 9100 litres.

Ibrahim et al., (2011) has determine that the important criteria for active protection system in the research which are detection and alarm system, automatic suppression system, fire hydrant, portable fire extinguisher, emergency lighting, hose reel/standpipe and communications.

2.6 Fire Management

A fire safety management framework specifies the procedures for establishing, controlling, monitoring, and amending fire safety regulations and ensuring that they are adhered to. The plan outlines the methods for effectively managing fire safety to prevent fires and safeguard persons and property in the case of a fire. The plan must detail the organisation, planning, monitoring, control, and evaluation of the fire safety procedures and provisions in the building.

Housekeeping and maintenance, a management fire safety plan, security, staff training, a fire officer or marshal, emergency response, and exterior exposure to fire, according to previous study, are the most significant aspects of a fire management system (Ibrahim et al., 2011).

2.7 Building Characteristic

Buildings must be built to provide an adequate level of fire protection while minimising heat and smoke concerns. The primary goal is to keep the risk of death or harm to building inhabitants and those who may become engaged, such as the fire and rescue service, to an acceptable level. Building construction has an impact on both fire behaviour and structural stability in the event of a fire. Non-combustible and fire-resistant construction do not contribute to the fuel load, although combustible and standard (masonry and wood) construction does. Protecting contents and ensuring that as much of a structure as feasible can continue to function after a fire - and that it can be repaired - are also critical.

Chow (2002) has stated important criteria of building characteristic for fire risk assessment which are building contents, building fabric/ material, architectural features, building status and historical significance.

2.8 Summary

Numerous studies on fire risk assessment have been undertaken, and numerous methodologies/frameworks have been developed. However, Ibrahim et al., (2011) illustrated the most thorough components of the fire risk framework, stressing the most important evaluation criteria for fire risk. As a result, we selected two important criteria (Passive and Active Protection System) to examine, and the specifics are provided in Chapter 3. Moreover, because this is the first study of its sort to be conducted on the engineering campus of USM, it will fulfil a critical research need. The method or score guideline will be utilise and alter the methods in accordance with the developed strategy (Ibrahim et al., 2011).

CHAPTER 3

METHODOLOGY

3.1 Overview

In this Chapter 3, the flow of study will be presented from the beginning of material finding based on the project proposal. The research will be undertaken in multiple stages to meet all of the objectives of this study. The first stage would involve establishing the objectives and scope of work involved. Once finalized, the second stage would be to conduct the literature research to find out more information on fire risk assessment and fire safety in general and find the weightage of fire risk assessment criteria, thereby achieving part of the first objective. This is also to ensure adequate understanding of the subject topic and to boost knowledge level. The third stage would involve conducting the field research from the case study chosen to fully achieve objectives and get the compliance rate of the building. The criteria that been picked are passive and active protection system for the checking. The weightage and all the requirements are being employed from the prior research due to keep the weightage value. The score checking would be based on a Ibrahim et al., (2011) of 0 (Lower Fire Safety) – 10 (High Fire Safety) . The fourth stage of study would be to assemble all the data obtained and do the analysis. The last stage would be the presenting of the examined data and authoring of the report with conclusions and future recommendations. A flowchart of the processes involved is provided in Figure 3.1.

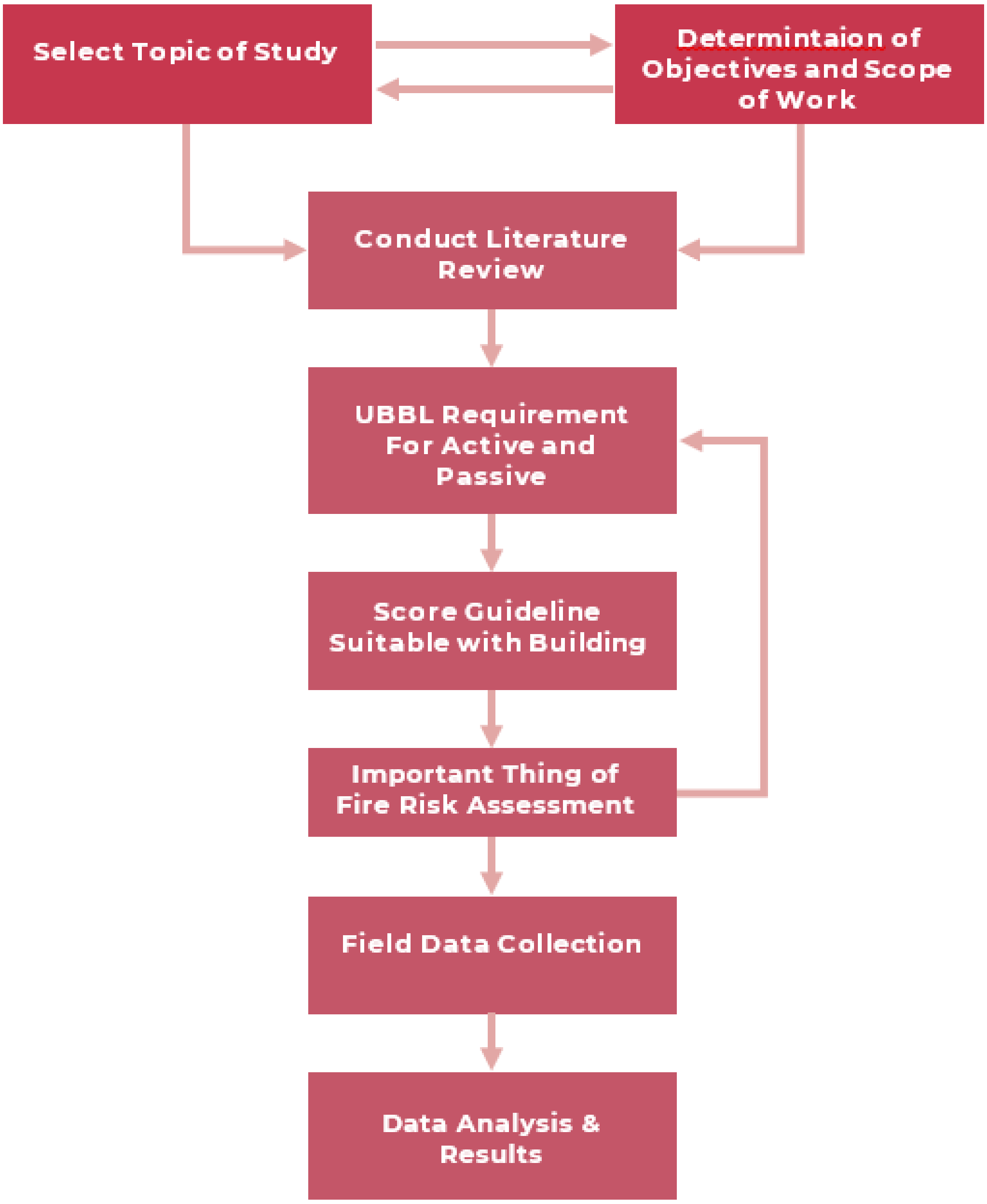

Figure 3.1: Research Methodology Flow Chart

3.2 Selected Building

In this research, there are 7 buildings that been selected between the building in USM Engineering Campus which are School of Civil Engineering, Laboratory Building of Civil Engineering, Library, School of Chemical Engineering, School of Mechanical Engineering, School of Materials And Mineral Resources Engineering and Hostel SH5. These buildings are selected due to the difference of used in the building. School of

Chemical is be selected because the building has a lot of chemical that flammable. School of Mechanical was chosen due to it contain electrical component which is it same with the School of Electrical. School of Civil and Material were selected because it differences to other school. Hostel SH5 and Library also been selected due to difference type with school building.

3.3 The Weightage Scale For The Passive And Active Criteria Of UBBL

The weightage that used in this research was decided by compared with former researcher. Numerous research on fire risk assessment have been done, and numerous methodologies/frameworks have been established. However, Ibrahim et al., (2011) demonstrated the most extensive components of the fire risk framework, emphasising the most significant evaluation criteria for fire risk. Hence, two significant criteria (Passive and Active Protection System) to investigate, and the specifics are supplied in Chapter 3. Moreover, because this is the first study of its like to be done on the engineering campus of USM, it will serve a key research requirement. This research will employ and adjust the procedures in accordance with the developed strategy by (Ibrahim et al., 2011).

3.4 Passive Protection System

When it comes to the prevention of fire hazards and reduction of fire risks, passive fire protection is primarily an issue of planning and needs to be taken into consideration during the planning stage of building design. During the planning stage, some of the most fundamental safety measures include the selection of materials, the subdivision of the building into fire-proof cells or compartments both vertically and horizontally, and the prevention of the spread of smoke, heat, and toxic fumes. Passive fire measures that are effective indicate smart planning, good design, and solid construction, all of which could support other fundamental functions of a structure. Compartmentation, an evacuation route, corridor width, the number of exits, the maximum travel distance, exit signs, and site accessibility are the seven requirements for a passive protection system. Figure 3.2 shows that the weightage for passive protection system that will be use in this project which is the percentage of each criteria were be taken from the past research. The form of the passive protection system is depicted in Figure 3.3. The score guideline has been made by refer to UBBL and some research due to the UBBL 1984 explained or described all the criteria to general.

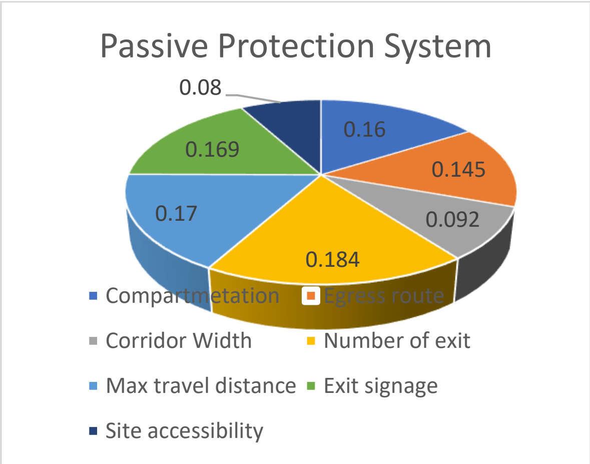

Figure 3.2: Weightage For Passive Protection System