JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF PUBLIC WORKS AND TOWN AND COUNTRY PLANNING (DPT),

MINISTRY OF INTERIOR (MOI)

THE STUDY

ON

DEVELOPMENT OF A BUILDING SAFETY SYSTEM

FOCUSING ON FIRE PREVENTION

IN

THE KINGDOM OF THAILAND

FINAL REPORT

VOLUME II

MAIN REPORT

FEBRUARY 2003

THE BUILDING CENTER OF JAPAN

NIPPON KOEI CO., LTD.

Monetary Exchange Rate
(Average Exchange Rate
as of January in 2003)

US$1 = 42.750 Baht

THE STUDY ON DEVELOPMENT
OF
A BUILDING SAFETY SYSTEM FOCUSING
ON
FIRE PREVENITON
IN
THE KINGDOM OF THAILAND

FINAL REPORT

VOLUME OF REPORT

VOLUME I SUMMARY

VOLUME II MAIN REPORT

VOLUME III TECHNICAL MANUAL FOR PLANNING OF FIRE PREVENTION SYSTEM

VOLUME IV APPENDIX

PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct the Study on Development of a Building Safety System Focusing on Fire Prevention in the Kingdom of Thailand and entrusted the study to the Japan International Cooperation Agency (JICA).

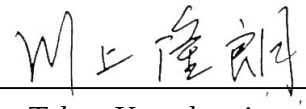
JICA selected and dispatched a study team headed by Mr. Yuji Kanaya of the Building Center of Japan, and consisted of the Building Center of Japan and Nippon Koei Co., Ltd., to the Kingdom of Thailand, seven times between July 2001 and January 2003. In addition, JICA set up an advisory committee headed by Mr. Kenya Itani, former Director for International Codes and Standards, Housing Bureau, Ministry of Land, Infrastructure and Transport between July 2001 and October 2002 and by Mr. Takashi Nagasaki, Director for International Codes and Standards, Housing Bureau, Ministry of Land, Infrastructure and Transport between October 2002 and January 2003, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Kingdom of Thailand and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the study.

February 2003



Takao Kawakami
President
Japan International Cooperation Agency

February, 2003

Mr. Takao Kawakami
President
Japan International Cooperation Agency
Tokyo, Japan

Subject: Letter of Transmittal

Dear Sir,

We are pleased to submit herewith the Final Report of the "Study on Development of a Building Safety System focusing on Fire Prevention in the Kingdom of Thailand". This study was conducted by the Building Center of Japan, in association with Nippon Koei Co., Ltd., under a contract to JICA, during the period from July 2001 to February 2003. The report consists of Summary, Main Text, Technical Manual, and Appendix.

The report presents recommendations for the development strategies for building safety systems in Thailand, which reflects the results of review on current situation related to building fires in Thailand and other countries.

We would like to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs. We are also most grateful for the cooperation and assistance from the officials concerned in Thailand, the JICA Bangkok office, and the Embassy of Japan in Thailand. The Final Report is a fruit of excellent collaboration of all participants in this study.

Yours Faithfully,

金谷 勇治

Yuji Kanaya
Team Leader, JICA Study Team
The Study on Development of a Building Safety System
Focusing on Fire Prevention System in
the Kingdom of Thailand

AUTHORITY

This is the Final Report on the Study on Development of a Building Safety System focusing on Fire Prevention in the Kingdom of Thailand prepared in accordance with the Scope of Work (S/W) concluded on February 9, 2001, between Public Works Department (reorganized to Department of Public Works and Town and Country Planning in 2002), the Ministry of Interior, Kingdom of Thailand and the Japan International Cooperation Agency (JICA).

BACKGROUND OF THE STUDY

Along with rapid economic development in recent years, large-scale and/or high-rise buildings have been rapidly built in Thailand, especially in Bangkok. However, the building fire and the structure collapse has become major concern, since the building regulations and standards are out-dated, judgment standard for building permission is indefinite, criteria of safe building design are different by each architect/engineer.

To cope with this situation, the government of Thailand has initiated several efforts such as amendment of the Building Control Act, enhancement of building inspection, and training of the persons concerned, but the number of the unsafe buildings are still increasing mainly because of lack of systematic legal structuring in the field. It therefore is an immediate desire to devise a comprehensive measure.

Under these circumstances, the Government of Thailand requested the Government of Japan to conduct a technical cooperation for a study aiming at formulation of a building safety system focusing on fire prevention.

OBJECTIVES OF THE STUDY

The Study has five objectives to improve fire prevention systems of special buildings as listed below.

1) Formulation of strategies for the fire prevention system development of both newly constructed buildings and existing buildings,
2) Recommendations on amendments of the building codes for the fire prevention system,
3) Recommendations on the technical manuals of the fire prevention system for building officials and building engineers,
4) Recommendations on human resource development programs, and
5) Evaluation of the possibility of establishing a technical center for the fire prevention.

TARGET AREA AND TYPE OF BUILDINGS

Supposing that the fire prevention system proposed by the Study be legislated in the future, the study area is basically set the whole country. However, since the area which has many large-scale/special buildings are limited to the Area of Bangkok Metropolitan Administration and some other regional cities, the Study puts emphasis on these areas.

The target buildings in the Study are those used by many or unspecified people, including ten kinds of building uses, namely; 1) hotel, 2) office building, 3) theater, 4) hospital, 5) school, 6) factory, 7) multi-story housing, 8) shop-house, 9) department store, and 10) complex.

RECOMMENDATIONS

1. Building Fire Safety System Development Strategy

(1) General Directions

Since a relatively small number of building fires have occurred in Thailand, many of problems to decline the fire safety of buildings are originated in the low attention and awareness of fire safety. Taking the socio-economic situation, administration systems, and the current building production system into consideration, the basic directions for the building safety system development are identified as listed below.

1) Strong Government Initiative,
2) Cooperation with Private Experts, and
3) Promotion of Forming the Society which accepts Fire Safety to be Economic Value

(2) Targets of Development and Fire Safety Level

Taking into consideration inadequate preparedness of fire fighting equipment and infrastructure, the target level of fire safety is set to secure life safety, while safety for properties is recognized as the secondary important target. Based on the general directions stated above, the following three points are recommended as the broad targets.

1) Securing of the new buildings to be constructed,
2) Improvement of the existing buildings, and
3) Improvement of the manner or use/operation in a building.

(3) Recommended Projects/Programs

The following projects/programs are recommended to realize the development target.

1) Expansion of Technical Regulation and Standard for Building Fire Safety:

to cover all the fire protection technologies with their installment requirements.

2) Reorganization and Expansion of the Related Documents: to formulate a legal system by three documents of the Building Standard Law, ASA standard (tentative name), and EIT standard.

3) Expansion of Permission/Inspection System: to implement inspection and supervision by engineers for buildings in use and under construction especially in the interior finish work stage.

4) Establishment of the Authorization System of Building Materials and Assembled Parts: to prepare an authorization system with testing and evaluation organizations in accordance with ISO standards.

5) Establishment of Financial Incentive Systems: to provide preferential systems for the improvement of existing buildings by the taxation, insurance rate, and interest rates in relation with grading of fire safety set by a new ministerial regulation.

6) Promotion of Information Distribution and Human Resources Development: to provide four activities: a) Establishment of Research Section, b) Cooperation with Research Organization, c) Capacity Building for Experts, d) Collaboration with Fire Departments.

2. Amendments of Fire Codes

(1) Introduction of Passive Systems: to newly specify the noncombustible interior finish, fire separation, and smoke enclosures in MRs.

(2) Proper Introduction of Active Systems: to introduce and strengthen the active systems, corresponding to the preparedness of fire fighting facilities and infrastructure by region.

(3) Establishment of Fire Codes Responding to Characteristics of Buildings: to modify the classification of buildings to be same with that specified in the EIT standard. The definition of hazardous materials in buildings needs to be specified.

(4) Proper Introduction of Fire Protection Systems:

- Strengthening installment of detection and alarming systems for facilities with sleeping occupants.
- Securing evacuation routes with sufficient capacity and smoke resistance.
- Introducing smoke-proof staircases.
- Securing smoke control by gravity and mechanical exhaust systems. Performance test should be introduced for the pressurized smoke control.

- Introducing the fire fighting control rooms.
- Introducing fire-resistance rating in relation with the scale and purpose of buildings.

(5) Improvement of Existing Unsafe Building: to improve on extra-large/high-rise buildings constructed before the issuance of MR 33 with the high priority. Improvements should aim to secure life safety by forming vertical opening protection and evacuation routes with adequate capacity and safety. In relation with the new MR, the improvement items should include options to correspond existing situation of each building.

3. Technical Manual for Planning of Fire Prevention System

A technical manual is designed so as to cover basic theories of fires and planning issues for every fire protection technology and each building use. It is expected to utilize this manual for a technical seminar for experts.

4. Human Resource Development Plan

It is recommended to establish a research section for the quantitative analysis of building construction trend and fires. In addition, collaboration with researcher and research organizations specialized in this field is recommended to promote research and development of specific issues. The results of analysis and research should be distributed to the experts as well as public. Technical seminars for experts in a private sector also need to be implemented.

5. Establishment of Testing System for Building Materials

It is recommended that a testing organization is established for the realization of authorization systems, that should have the test equipment in accordance with ISO standard.

- Furnaces for Fire-Resistance Tests (ISO834) for three elements: 1) Columns, 2) Vertical elements, and 3) Horizontal elements.
- Equipment for Fire Tests of Building Materials in six fields: Non-combustibility test (ISO1182), Ignitability test (ISO5657), Reduce scale model box test (DIS17431), Heat release, smoke production, and mass loss rate test (ISO5660), Full scale room test (ISO9705), and Toxic gas test.

It is expected that the testing equipment provided for fire test demonstration will be utilized for the testing organization. The equipment conforms to the requirements of ISO standards.

VOLUME II: MAIN REPORT

TABLE OF CONTENTS

Page

Preface
Letter of Transmittal
Executive Summary
Abbreviations
Measurement Units

INTRODUCTION 1
(1) Background I-1
(2) Objectives of the Study I-1
(3) Target Area and Type of Buildings I-2
(4) Study Outputs I-2
(5) Composition of Report and Technical Manual I-2
(6) Terminology I-3

PART I: BUILDING FIRE SAFETY SYSTEM DEVELOPMENT STRATEGY I-1
CHAPTER 1: OBJECTIVES OF THE BUILDING FIRE SAFETY SYSTEM DEVELOPMENT I-1
1.1 Importance of the Fire Safety Systems Development I-1
1.2 Viewpoints I-1

CHAPTER 2: REVIEW ON CURRENT SITUATIONS RELATED TO BUILDING FIRES I-3
2.1 Socio-economy I-3
2.1.1 Population I-3
2.1.2 Macroeconomy I-3

2.2 Construction Trend I-4
2.2.1 Overview I-4
2.2.2 Trend of Construction I-4
2.3 Fire Outbreak Situation I-6
2.3.1 Major Accidents related to Buildings I-6
2.3.2 Situation of Outbreak of Fire I-6
2.3.3 Cause of Outbreak of Fire I-8
2.4 Fire-Fighting System I-8
2.4.1 Fire-fighting Organization I-8
2.4.2 Fire Fighting Facilities I-8
2.4.3 Other Activities I-9
2.5 Fire Insurance I-9
2.5.1 Subscription I-9
2.5.2 Premium Rate I-10
2.5.3 Fire Safety Promotion I-10

CHAPTER 3: COMMON PRACTICE OF BUILDING INDUSTRY I-11
3.1 Overview I-11
3.1.1 Structure and Material I-11
3.1.2 Fire Protection Equipment I-12
3.2 Consideration for Existing Fire Prevention System I-13

CHAPTER 4: REVIEW OF BUILDING CONSTRUCTION SYSTEM I-15
4.1 Human Resources for Building Industry I-15
4.1.1 Educational System I-15
4.1.2 Qualification System I-15
4.1.3 Associations for Building Industry I-16
4.2 Construction Production / Management System I-16
4.2.1 Stage of Feasibility Study and Building Permissions I-16
4.2.2 Stage for Ordering Construction Work I-16
4.2.3 Construction Stage I-17
4.2.4 Management Stage I-18
4.3 Building Administration I-18
4.3.1 Organization I-18
4.3.2 Assessment I-19
4.3.3 Inspection I-19

4.4 Acts and Regulations related to Building Control I-19
4.4.1 Related Act I-19
4.4.2 Composition of Building Control Act I-20
4.4.3 Contents of Ministerial Regulations for Fire Prevention I-24
4.4.4 Testing and Evaluation Systems for Building Materials and Assembled Parts I-25

CHAPTER 5: IDENTIFICATION OF PROBLEMS I-27
5.1 Problem Structure I-27
5.2 Analysis of Major Problems I-29
5.3 On going Efforts and Their Limitations I-31
5.3.1 Revision of the EIT Standard I-31
5.3.2 Enforcement of a New Ministerial Regulation I-32

CHAPTER 6: BUILDING FIRE SAFETY SYSTEM DEVELOPMENT STRATEGY I-33
6.1 General Directions I-33
6.2 Development Targets and Concept for Fire Safety Level I-34
6.3 Recommended Projects/Programs I-34
6.3.1 Expansion of Technical Regulation and Standard for Building Fire Safety I-36
6.3.2 Reorganization and Expansion of the Related Documents I-36
6.3.3 Expansion of Permission / Inspection System I-38
6.3.4 Establishment of the Authorization System of Building Materials and Assembled Parts I-39
6.3.5 Establishment of Financial Incentive Systems I-41
6.3.6 Promotion of Information Distribution and Human Resources Development I-43
6.4 Implementation Schedule I-46
6.4.1 Implementation Schedule I-46
6.4.2 Project Programs I-47

PART II: REVIEW ON EXISTING FIRE CODES IN DIFFERENT COUNTRIES AND THAILAND II-1
CHAPTER 7: FIRE CODES IN DEFFERENT COUNTRIES II-1
7.1 Elemental Knowledge of Fire Prevention System II-1
7.1.1 Basic Theories of Fire II-1

7.1.2 Basic Theories of Fire Prevention System II-2
7.2 Fire Codes in Different Countries II-15
7.2.1 Basic Composition of Fire Codes in Different Countries II-15
7.2.2 Fire Prevention System in Fire Codes in Foreign Countries II-18
7.2.3 Technical Limitations of Verification of Fire Safety and Improvement of Fire Codes II-23

CHAPTER 8: FIRE CODES AND FIRE PROTECTON SYSTEMS IN THAILAND II-33
8.1 Existing Fire Codes in Thailand II-33
8.1.1 Ministerial Regulations under the Building Control Act II-33
8.1.2 Technical Requirements for the Fire Prevention System II-38
8.1.3 EIT Standard II-48
8.2 Analysis on Major Building Fires II-52
8.2.1 Fire at the Kader Doll Factory II-52
8.2.2 Fire at the Royal Jomtien Resort Hotel II-55
8.3 Fire Prevention System of Existing Buildings II-58
8.3.1 Interview Survey on the Existing Buildings II-58
8.3.2 On-site Survey of the Existing Buildings II-63
8.3.3 Consideration on the Fire Prevention System of Existing Buildings II-64

PART III: RECOMMENDATIONS ON FIRE CODES AND TECHNICAL STANDARDS III-1
CHAPTER 9: POINTS OF VIEW FOR RECOMMENDATION III-1
9.1 Purposes of Recommendation III-1
9.2 Significance of Recommendation III-1
9.3 Points of View for Recommendation III-2
9.4 Prerequisite for Recommendation III-5

CHAPTER 10: MAIN POINTS OF RECOMMENDATION ON TECHNICAL REQUIREMENTS III-6
10.1 Prevention of Outbreak of Fire III-6
10.2 Prevention of Initial Fire Development III-7
10.2.1 Detection and Report/Alarm III-7
10.2.2 Initial Fire Extinguishing III-11
10.2.3 Use of Noncombustible Materials for Interior Finish III-15

10.2.4 Use of Noncombustible Furniture and Goods III-19
10.3 Prevention of Fire Spread (Introduction of Fire Separation).....III-21
10.4 Evacuation III-26
10.4.1 Proper Evacuation Routes.....III-26
10.4.2 Proper Installation of Escape Stairway.....III-32
10.4.3 Horizontal Exit (Exit strengthening the redundancy and smoothness in evacuation).....III-34
10.4.4 Exit Discharge III-36
10.4.5 Locking and Direction of Open and Shut for Door III-37
10.4.6 Emergency Lighting and Exit Sign Facilities.....III-38
10.4.7 Smoke Control.....III-39
10.5 Fire Fighting and Rescue.....III-42
10.5.1 Access for Firefighters.....III-42
10.5.2 Fire Fighting Equipment, etc. III-42
10.6 Prevention of Building Collapse.....III-46
10.7 Classification and Definition of a Building.....III-51

CHAPTER 11:IMPROVEMENT OF EXISTING BUILDINGS III-54
11.1 Outline of Existing System.....III-54
11.2 Approach to the Improvement of Existing Building III-55
11.3 Recommendation of Amendment on the Ministerial Regulations.....III-56
11.4 Case Study for Improvement of Existing and Newly Constructed Buildings.....III-57
11.4.1 Methodology of the Case Study III-57
11.4.2 Results of the Case Study III-58

CHAPTER 12: RECOMMENDATION OF AMENDMENT OF MINISTERIAL REGULATIONS BY ARTICLE.....III-60
12.1 Points of recommendations III-60
12.2 Ministerial Regulations No. 33 and No. 50 .....III-60
12.3 Ministerial regulation No. 39.....III-63
12.4 Ministerial regulation No. 47.....III-65
12.5 Ministerial regulation No. 48.....III-66
12.6 Ministerial regulation No. 55.....III-67

LIST OF TABLES

Table 2.1: Population Distribution by Region I-3
Table 2.2: Economic Growth Indexes I-4
Table 2.3: Cause of Fire in 1999 ..... I-8
Table 4.1: Classification of Laws related to Building by Objectives I-20
Table 4.2: Existing Ministerial Regulations under the Building Control Act I-22
Table 6.1: Project Design Matrix for Establishment of Testing Organization I-49
Table 7.1: Requirement of the Fire Protection System in Fire Codes of Six Countries II-22
Table 7.2: Amendments of the Building Standard Law in Japan II-27
Table 7.3: Losses in Japan by Classification of Building (Year 2000) II-29
Table 7.4: Fire Loss and Public Fire Service in the Four Countries II-31
Table 7.5: Fire Losses and Public Fire Service in Major Cities II-32
Table 8.1: Ministerial Regulations for the Fire Protection System II-34
Table 8.2: Classification of Building II-36
Table 8.3: Technical Requirements of the Ministerial Regulation No.33 and No.50 ..... II-39
Table 8.4: Technical Requirements in the Ministerial Regulation No.39 ..... II-42
Table 8.5: Technical Requirements in the Ministerial Regulation No.48 ..... II-44
Table 8.6: Technical Requirements in the Ministerial Regulation No.55 (Structure) II-44
Table 8.7: Technical Requirements in the Ministerial Regulation No.55 (Escape Stairway) II-45
Table 8.8: Technical Requirements in the Ministerial Regulations II-47
Table 8.9: Classification of Building by the EIT Standard II-49
Table 8.10: Fire Protection System of the EIT Standard II-51
Table 8.11: Problematic Issues of the Fire at the Kader Doll Factory II-54
Table 8.12: Outline of the Fire at the Royal Jomtien Resort Hotel II-55
Table 8.13: Problematical Issues of the Fire at the Royal Jomtien Resort Hotel II-57
Table 8.14: Investigation Items by the Straight Choice between Two Alternatives II-59
Table 8.15: Improper Design and Maintenance of the Fire Prevention System II-64
Table 10.1: Requirements for Detectors III-8
Table 10.2: Selection of Detectors (the Fire Service Law in Japan) III-9
Table 10.3: Requirements for Alarming System III-10
Table 10.4: Requirements of Automatic Sprinkler System III-13
Table 10.5: Technical Standard for Automatic Sprinkler System III-14

Table 10.6: Requirements for Noncombustible Interior Finish III-17
Table 10.7: Fire Testing for Materials of Noncombustible Interior Finish III-18
Table 10.8: Requirements for Goods in a Building III-20
Table 10.9: Requirements for Fire Separation III-23
Table 10.10: Fire-resistant Rating of the Fire Separation III-24
Table 10.11: Fire Protection at Openings and Penetrated Part of Fire Separation III-25
Table 10.12: Occupant Density (Occupant/m^2) III-29
Table 10.13: Width of Evacuation Route III-29
Table 10.14: Multiple Evacuation Routes III-31
Table 10.15: Maximum Exit Access Travel Distance and Maximum Common Path of Exit Access Travel III-31
Table 10.16: Type of Escape Stairways III-33
Table 10.17: Form of Escape Stairways III-34
Table 10.18: Requirements of Indoor Fire Hydrant III-44
Table 10.19: Requirements for Outdoor Fire Hydrant and Fire Department Hydrant III-45
Table 10.20: Type of Construction by Scale of a Building (MR and EIT) III-48
Table 10.21: Type of Construction by Sale of a Building (BSL and IBC) III-48
Table 10.22: Fire-resistant Rating in the MRs, EIT Standard, BSL, and IBC III-49
Table 10.23: Fire Testing Standards III-50
Table 10.24: Classification of Building in the Building Standard Law (JPN) and the International Building Code (US) III-52
Table 10.25: Classification of Building in the Building Act (ENG) and the Building Code of Australia III-53
Table 11.1: Improvement Cost of New Buildings III-58
Table 11.2: Improvement Cost of Existing Buildings III-59

LIST OF FIGURES

Figure 2.1: Building Permission Trend I-5
Figure 2.2: Number of High-rise Buildings permitted by the BMA Headquarter in 1992 - 1999 ..... I-5
Figure 2.3: Trend of Fire Accidents in Thailand I-6
Figure 2.4: Fire Accidents in BMA I-7
Figure 5.1: Problem Structure I-28
Figure 6.1: Projects/Programs for Development Targets I-35

Figure 6.2: Implementation Schedule I-46
Figure 7.1: Four Elements of Fire (Combustion) II-1
Figure 7.2: Temperature and Gas Concentration by Development Stages of Fire in a Separated Room II-2
Figure 7.3: Fire Prevention System in the Seven Categories II-12
Figure 7.4: Building Features related with Fire II-14
Figure 7.5: Rational Safety Level (Total Amount of Construction Cost and Expected Loss) II-24
Figure 7.6: Loss by Fires in Japan and in USA II-28
Figure 8.1: Outline of the Fire at the Kader Doll Factory II-52
Figure 8.2: Fire Development of the Fire at the Royal Jomtien Resort Hotel II-56
Figure 8.3: Profile of the Surveyed Existing Buildings II-58
Figure 8.4: Fire Prevention System of Surveyed Buildings II-61
Figure 8.5: Evacuation Facilities and Smoke Control System II-62
Figure 8.6: Access for Fire Fighting II-62
Figure 8.7: Periodical Inspection II-63
Figure 10.1: Pressurization System for Vertical Openings III-41
Figure 10.2: Heat Velocity and Time III-41
Figure 10.3: Height of Smoke Layer by Time III-42

ABBREVIATIONS

ACB	Appeal Committee Board
AD	Approved Document under the Building Act of England
ALC	Autoclaved Lightweight Concrete
ANSI	American National Standard Institute
APLAC	Asian Pacific Laboratory Accreditation Cooperation
ASA	Association of Siamese Architects
ASTM	American Society for Testing and Materials
ASTM E 84	Standard Test Method for Surface Burning Characteristics of Building Materials
ASTM E 119	Standard Test Methods for Fire Tests of Building Construction and Materials
AUS	Australia
AWWA	American Water Works Association
BA	Building Act of England
BBL	Bangkok By-Law
BCA	Building Code of Thailand
BCCB	Building Control Committee Board
BFIC	Building Fire Inspectors Club
BMA	Bangkok Metropolitan Administration
BMA area	Area of Bangkok Metropolitan Administration
BS	British Standard
BS 476	Fire Tests on Building Materials and Structures
BSL	Building Standard Law of Japan
CO	Carbon Monoxide
CO_2	Carbon Dioxide
DOLA	Department of Local Administration
DPT	Department of Public Works and Town and Country Planning
DTCP	Department of Town and Country Planning
EIT	Engineering Institute of Thailand
EN	European Standard
ENG	England
F/S	Feasibility Study
FSL	Fire Service Law of Japan
GDP	Gross Domestic Product

IBC	International Building Code in the United States of America
ICU	Intensive Care Unit
IFC	International Building Code in the United States of America
IND	Indonesia
ISO	International Organization for Standardization
ISO 834	Fire-resistance Tests - Elements of Building Construction
ISO 1182	Reaction to Fire Tests for Building Products - Non-combustibility Test
ISO 5657	Reaction to Fire Tests - Ignitability of Building Products Using A Radiant Heat Source
ISO 5660	Reaction to Fire Tests - Heat Release, Smoke Production and Mass Loss Rate from Building Products
ISO 9705	Fire Tests--Full Scale Room Test for Surface Products
ISO17025	General Requirements for the Competence of Calibration and Testing Laboratories
ISO17065	General Requirements for Bodies Operation Product Certification System
ISO DIS 17431	Fire Tests - Reduce Scale Model Box Test
JPN	Japan
MAL	Malaysia
MR	Ministerial Regulation
NBC	National Building Code of Indonesia
NESDB	National Economic and Social Development Board
NFPA	National Fire Protection Association
NFPA 253	Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using A Radian heat Energy Source
NSO	National Statistical Office
OACB	Office of Appeal Committee Board
OBCCB	Office of Building Control Committee Board
ONAC	Office for National Accreditation Council
PWD	Public Works Department
RC	Reinforced Concrete
S/V	Supervision
Study	The Study on Development of a Building Safety System focusing on Fire Prevention in the Kingdom of Thailand
TIS	Thai Industrial Standard
TISI	Thai Industrial Standard Institute

UBB	Uniform Building By-laws 1984 of Malaysia
UBC	Uniform Building Code of the United States of America
USA	United States of America
WFTAO	World Federation of Technical Assessment Organizations

MEASUREMENT UNITS

Extent

cm^2 = Square-centimeters
m^2 = Square-meters
km^2 = Square-kilometers
ha. = Hectares (10,000 m^2)
rai = 0.16 Hectares

Volume

cm^3 = Cubic-centimeters
m^3 = cu.m = Cubic-meters
l = Liter

Length

mm = Millimeters
cm = Centimeters (cm = 10 mm)
m = Meters (m = 100 cm)
km = Kilometers (km = 1,000 m)
wah = 2 Meter

Weight

g = Grams
kg = Kilograms
ton, t = Metric tonne

Energy

kcal = Kilocalories
W = Watt
kW = Kilowatt
V = Volt
kV = Kilovolt
MJ = Megajoule

Time

sec, s = Seconds
min = Minutes
h, hr = Hour
d = Day

Others

% = Percent
^0C = Degree Celsius
K = Kelvin
lx = Lux
KP = Kilopascal
MP = Megapascal

INTRODUCTION TO THE STUDY

(1) BACKGROUND

Along with the rapid economic development in recent years, large-scale and/or high-rise buildings, such as office buildings, hotels, and shopping centers, have been rapidly built in Thailand, especially in Bangkok. Most of these buildings have been developed in and after 1990's. However, the building fire and the structure collapse has become a major concern, since the building regulations and standards are indefinite and out-dated, the judgment standard for building permissions is indefinite, and the criteria of safe building design decisions are different for each architect/engineer.

To cope with this situation, the government of Thailand, especially the Building Control Committee Board in the Ministry of Interior, has initiated several efforts such as amendment of the Building Control Act, enhancement of building inspection, and training of persons concerned, but the number of unsafe buildings is still increasing, mainly because of a lack of a systematic legal structuring and its enforcement system in the field. Therefore it is an immediate desire to devise a comprehensive measure.

Under these circumstances, the Government of Thailand requested from the Government of Japan technical cooperation to conduct a study to improve the building safety system, focusing on the fire safety of those buildings used by many unspecified persons.

(2) OBJECTIVES OF THE STUDY

The Study has five objectives for the improvement of the fire prevention system in special buildings (hotels, offices, theaters, hospitals, schools, factories, multi-story housings, etc) in accordance with the Scope of Works (S/W) agreed between the Public Works Department, the Ministry of Interior (After the mutual agreement, the Public Works Department was amalgamated with the Department of Town and Country Planning, and renamed the Department of Public Works and Town and Country Planning, due to the restructuring of the central governments in Thailand.) and the Japan International Cooperation Agency on February 9, 2001. Those objectives are:

- Formulation of strategies for the fire prevention system development of both newly constructed buildings and existing buildings,
- Recommendations on amendments of the building codes for the fire prevention system,
- Recommendations on the technical manuals of the fire prevention system for

building officials and building engineers,

- Recommendations on human resource development programs, and
- Evaluation of the possibility of establishing a technical center for fire prevention.

(3) TARGET AREA AND TYPE OF BUILDINGS

Assuming that the fire prevention system proposed by the Study will be legislated in the future, the study area is basically set for the whole country. However, since the area which has many large-scale/special buildings of targeted buildings in the Study is limited to the Area of Bangkok Metropolitan Administration (BMA area) and some other regional cities, the Study puts emphasis on these areas.

The target buildings in the Study are those used by many or unspecified people, including ten kinds of building uses, namely; 1) hotel, 2) office building, 3) theater, 4) hospital, 5) school, 6) factory, 7) multi-story housing, 8) shop-house, 9) department store, and 10) complex. Low-rise wooden frame buildings such as detached house and inferior low-rise buildings in a densely built-up area are excluded from the target buildings.

(4) STUDY OUTPUTS

For the Study, five booklets are formulated. These are: 1) a Japanese summary, 2) an English summary, 3) a Main Report, 4) a Technical Manual, and 5) an Appendix. In addition to these texts, a demonstration of the combustibility testing of some building materials was performed in Thailand.

(5) COMPOSITION OF REPORT AND TECHNICAL MANUAL

The composition of the main report and the technical manual are as follows:

i) Main Report

Part I: Building Fire Safety System Development Strategy

After widely reviewing the matter in connection with the prevention of building fire, the current problems are identified, principles of building fire safety system development are stated, and the proposal for strategic measures are presented.

Part II: Review on Existing Fire Codes in Different Countries and Thailand

Based on a basic theory of fire and fire prevention, fire codes in different countries and the effectiveness by these codes are reviewed. This examination is turned to advantage for reviews on major building fires and fire prevention system, and to point out problematical issues for fire codes in Thailand.

Part III: Recommendations on Fire Codes and Technical Standards

Among the strategic measures proposed in Part I, legal requirements and standards are focused as the highest importance. The improvement and expansion of legal requirements and technical standards are recommended.

ii) Technical Manual for Planning of Fire Prevention System

Part I: Fire Protection System in General

The purpose and basic concept of a fire protection system is presented based on the principles of fire and fire extinguishing.

Part II: Fire Protection System in Particulars

Planning issue on essential technologies of a fire protection system are presented.

Part III: Fire Protection System By Classification of Building

Planning issues of a fire protection system by the classification of building are pointed out.

(6) TERMINOLOGY

In this report, the following technical terms are particularly defined as mentioned below.

"**Fire Prevention**" means any activities and/or conditions to prevent outbreak of fire and the losses of lives and properties in case of fires. "Fire Prevention System" means systematic components to prevent the fire outbreak and fire losses. It includes, but not limited to, legal, administrative, and organizational systems as well as physical provisions of buildings.

"**Fire Protection**" focuses on any activities and/or conditions to prevent fire losses after the fire outbreak, while the fire prevention covers activities before the fire outbreak. "Fire Protection System" particularly means any physical fire preventive provisions of buildings, such as fire resistant structure and equipment.

"**Classification of Building**" defines types of buildings by the scale and purpose of buildings. Building use means to defines types of buildings by their purposes.

"**Fire Codes**" means a set of legal documents including, but not limited to, acts/laws, regulations, orders, by-laws/ordinances, and standards having requirements for fire prevention of buildings.

PART I BUILDING FIRE SAFETY SYSTEM DEVELOPMENT STRATEGY

CHAPTER ONE:
OBJECTIVES OF THE BUILDING FIRE SAFETY SYSTEM DEVELOPMENT

1.1 IMPORTANCE OF THE FIRE SAFETY SYSTEMS DEVELOPMENT

In order to raise the fire safety performance of a building, consideration should be given not only to the individual aspects of each separate specific field, but also to the influence from the building administrator's organization, fire-fighting organizations, the fire insurance system and the customs of the building users, etc., on top of the physical characteristics of the building, made by the efforts of the design and construction works.

The building fire safety system is formed by the interactions among these various aspects. It is therefore necessary to synthetically consider the various activities by subject for the development of a building fire safety system, and to generate a systematic plan with applicable measures.

1.2 VIEWPOINTS

The purpose of the building fire safety system development is to develop a total system that produces better safety to building fire accidents. The system requires the cooperation of the various people mentioned above. Therefore, in theory, it is desirable to grasp the actual conditions of all the persons/organizations concerned as much as possible and generate plans to detail their necessary actions. The comprehension works on the current conditions will need to analyze the knowledge level, technical level, and possibility of future improvement of the persons concerned. On the other hand, under certain circumstances, it is recognized that it may not be appropriate to draw up an action plan, for the use of individual citizens or private sector businesses through the hands of the government body.

To cope with this challenging task, the Study has focused on the activities of the administrative body in charge of the building controls in the country, in terms of recommending the plans.

In Part I of this report:

- The social conditions concerning a building fire are extensively reviewed (Chapters 2, 3, and 4),
- The social characteristics and problems in the current situation are identified (Chapter 5),
- The development policy of a building fire safety system is examined, and projects/programs are generated and proposed which are implemented along with

the amendment of building codes (Chapter 6).

CHAPTER TWO:
REVIEW ON CURRENT SITUATIONS RELATED TO BUILDING FIRES

2.1 SOCIO-ECONOMY

2.1.1 Population

The total population in Thailand is 61,661,701 according to the registered records of 1999, which are the latest statistics published by the Department of Local Administration (DOLA). The annual population increase rate has attained a low level increase (of less than 2%) as a result of introducing a population control policy in the second national economic and social development plan. The urban population distribution is characterized by a strong concentration in the capital city of Bangkok. Among the total urban population, the share of the Bangkok Metropolitan Administration (BMA) accounted for around 50%.

Table 2.1: Population Distribution by Region

Name of Area	Total Population*[1] (Persons)	Urban Population*[2] (Persons)	Urban population Ratio (%)	Area (km2)	Population Density (Person/km^2)
Whole Kingdom	61,661,701	11,409,488	18.5%	513,115	120.17
	100.0%	100.0%		100.0%	
Bangkok Metropolis	5,662,499	5,647,799	99.7%	1,565	3,618.21
	9.2%	49.5%		0.3%	
Vicinity of Bangkok	3,646,425	1,141,091	31.3%	6,193	588.80
	5.9%	10.0%		1.2%	
Sub-central Region	2,963,535	332,410	11.2%	16,593	178.60
	4.8%	2.9%		3.2%	
Other Regions	49,389,242	4,288,188	8.7%	488,763	101.05
	80.1%	37.6%		95.3%	

Source: Department of Local Administration, Ministry of Interior.
Note: *1) Statistics in 1999 and *2) Statistics in 1998.

2.1.2 Macroeconomy

According to the statistics of the National Economic and Social Development Board (NESDB), the gross domestic product (GDP) in 1999 was 2,860,956 million bahts, and the GDP per capita was 76,390 bahts. The Thai economy experienced minus growth after the currency crisis in 1997, and its growth to date has been stagnant, however, the economy has recovered at present. Moreover, according to the report, the economy will start to become prosperous in the near future.

Urban primacy of Bangkok is still going on in the economic activities of Thailand. The distinction between the BMA and local areas in per capita GDP is about twice. However, the distinction becomes smaller in recent years.

Table 2.2: Economic Growth Indexes

Item	1994	95	96	97	98P	99P
GDP (net, M. Baht)	2,695,413	2,935,341	3,109.320	3,057,009	2,746,128	2.860,956
Rate of growth (%)	9.0	8.9	5.9	-1.7	-10.2	4.2
GDP (net, M. Baht)	3,634,496	4,185,629	4,608,491	4,727,318	4,635,925	4,702,899
Rate of growth (%)	14.6	15.2	10.1	2.6	-1.9	1.4
Per capita GDP (Baht)	61,900	70,610	77,080	78,181	75,823	76,390
Equivalent US$	2,461	2,834	3,041	2,493	1,833	2,019
Population (year center, 10 thousand)	5,910	5,946	6012	6,082	6,147	6,156
Rate of growth (%)	1.30	0.62	1.10	1.16	1.07	0.15
Foreign exchange rate (US$/Baht)	25.150	24.915	25.343	31.364	41.359	37.844

Note: P = prompt statistics
Source: GDPs: NESDB statistics, Population: Annual report of Ministry of Interior, Exchange rate: IMF and IFS

2.2 CONSTRUCTION TREND

2.2.1 Overview

The construction industry was the most influenced by the currency crisis. The condition of the industry still has not recovered perfectly at present, however, according to a newspaper report, in response to the latest low interest rates and economic prosperity, a construction boom is rising again.

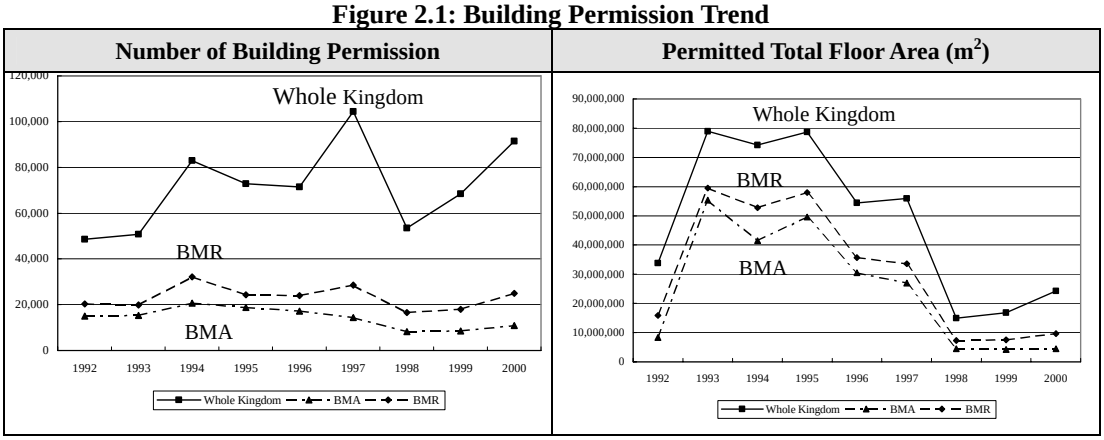
The construction industry had experienced two economic booms in the past. In the first economic boom, from 1981 to 1984, large-scale buildings were constructed, such as shopping centers, offices, high-class apartments and condominiums in BMA. In the second boom, from 1987 to 1996, large office buildings and condominiums were again developed in Bangkok with the development of industrial factories in the surroundings of BMA and large-scale hotels in the resort areas.

2.2.2 Trend of Construction

According to the statistics by National Statistical Office (NSO), the number of building permission given in 2000 was 91,493. This is 87.6% of the number allocated in 1997, the year of the highest record with 104,432 cases. The total floor area permitted in 2000 was 24,305,500 m^2, which is only 31% of the level allocated in 1993. Therefore, in spite of the recovery of the building permission allocations, the permitted large-scale buildings still remains at the lower level in 2000.

Looking at the permitted floor areas by building use, the share of the use outside of residential building use, such as commercial, public, and industrial, etc., was 75.1% (59,273,085m^2) in 1993, and 69.0% (54,293,219m^2) in 1995. However, the share after 1998 has been about 40%. No data for high rise building is available, but it is observed that most of them concentrate in Bangkok.

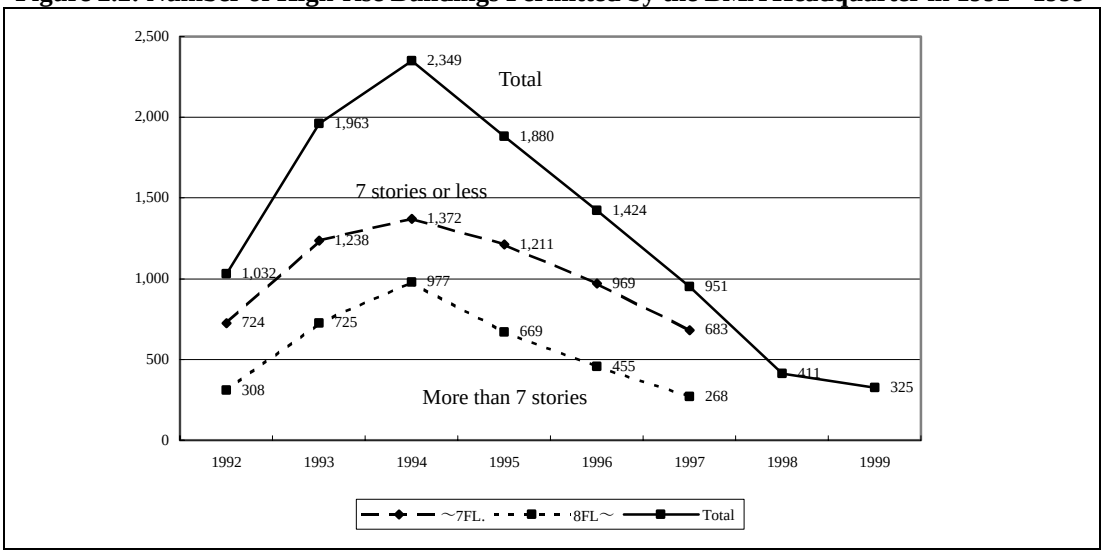
Figure 2.1: Building Permission Trend



Source: Statistics by National Statistical Office

According to the statistics of the Building Control Division of Public Works Department (PWD) in the Bangkok Metropolitan Administration (BMA), the total number of buildings with 7 or more stories built from1992 to 1997 was 3,402. The number of building permissions dropped from 669 buildings in 1995 to 268 buildings in 1997. At present, 369 buildings have experienced the suspension of construction due to the currency crisis in 1997.

Figure 2.2: Number of High-rise Buildings Permitted by the BMA Headquarter in 1992 - 1999



Source: Building Control Division, Bangkok Metropolitan Administration
Note: Number of buildings is permitted by BMA headquarter and excludes the record of district offices. The permission record classified by the number of floors, in 1998 and 1999 has not been obtained in the 1st field survey in Thailand.

2.3 FIRE OUTBREAK SITUATION

2.3.1 Major Accidents Related to Buildings

There are two types of accidents relating to buildings. One is “Building Collapse”, the other is “Fire Accident”. According to the analysis examination on major building accidents in the past, building collapses result from illegal expansions and modifications on the building structure while building fire accidents can occur in a building considered to be conforming to current building codes.

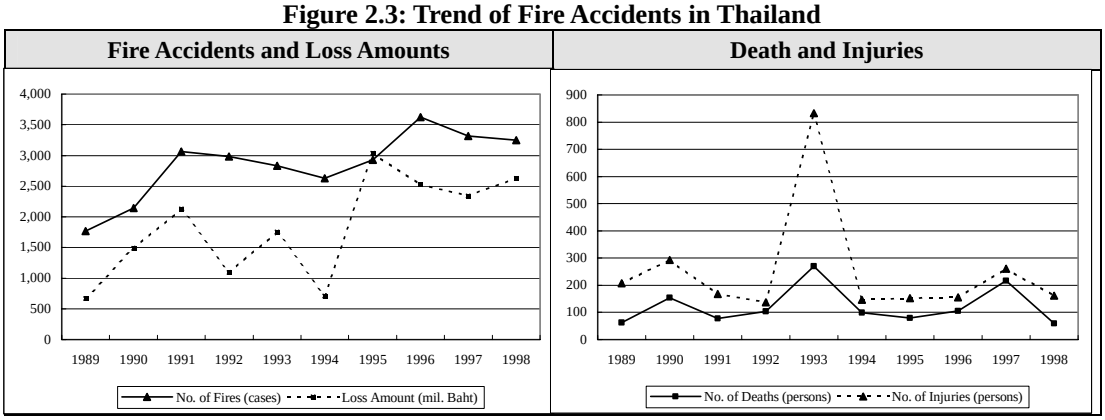
2.3.2 Situation of Outbreak of Fire

The trend in the number of fire outbreaks seems to be related to economic growth. The number of fires in 1996 was 3,622 which was the year of the highest record, and the loss amount in 1995 was 3,039 million baht which is also the highest record within the 10 years from 1989 to 1998.

The death toll due to fire accidents has fluctuated significantly. In years when a terrible disaster arose, the death toll tended to be greater. An annual death toll of 60 to 150 is usual. However, the death toll in 1993 and 1997 was higher than in any other years. In 1993, a fire accident at Kader Doll Factory in Nakhon Pathom caused 188 deaths. In 1997, a fire accident at the Royal Jomthien Resort Hotel in Pataya caused 91 deaths.

Looking at the number of fires, the loss amount, and the number of causalities by area, the number in the Bangkok is overwhelms the others. According to the statistics in 1997 by the Disaster Prevention Subdivision of the Ministry of Interior, 616 cases of fire accident in BMA was the highest among all provinces, followed by 112 cases in Udon Thani.

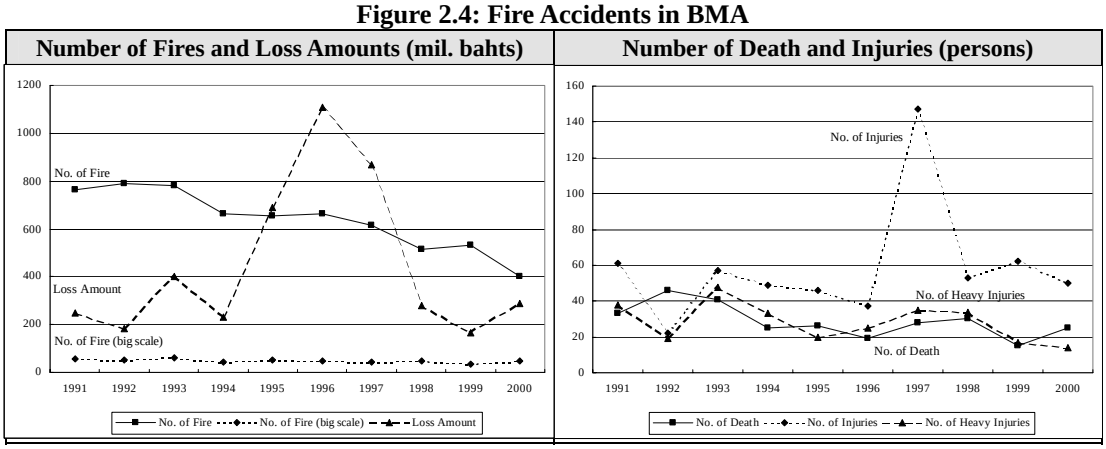
Figure 2.3: Trend of Fire Accidents in Thailand



Source: Disaster Prevention Subdivision, Department of Local Administration, Ministry of Interior

In Bangkok, the number of fires has decreased between 1991 and 2000. However the big fires, which have caused death, damaged area more than 1,600 m^2, or loss amounts more than 1,000,000 baht (as defined by the Metropolitan Fire Brigade) have steadily stayed at a high rate of around 10%.

Figure 2.4: Fire Accidents in BMA



Source: Metropolitan Fire Brigade
Note: Big fire means the fire causing death or loss amount more than 1 million baht, or damaged area more than 1,600m^2 (1 rai).

The number of fires by building use in the whole country are classified into 5 types, consisting of residence, government office, temple, school, and others. Residence recorded the highest of 3,739 fires in 1997, followed by temple (93 fires). Furthermore government offices and schools experienced 25 and 24 fires respectively.

2.3.3 Cause of Outbreak of Fire

Most causes of fires in the BMA have not been identified, as about 80% of the fires were classified into “Under Consideration”, according to the statistics by the Metropolitan Fire Brigade. Under this condition, the largest cause of fire was “electricity short circuit”, amounting to 5.8% and followed by “Buddha worship” of 3.8% and “outbreak in kitchen” of 2.8%.

Regarding the seasonal change of the fires, there was no considerable difference between the rainy season (May - October) and the dry season (November - April) in BMA in 1999, though the dry season is higher at 62% than the rainy season of 38% in the country. No discernable difference identified by time zones for the outbreak of fire.

Table 2.3: Cause of Fire in 1999

Cause of Fire		Number in Cases	Share (%)
1	Electricity short circuit	31	5.8
2	Buddha worship	20	3.8
3	Car short circuit	17	3.2
4	Cooking	15	2.8
5	Car accident	10	1.9
6	Leaking gas	5	0.9
7	Car collided with electricity pall and bridge	4	0.8
8	Widely spread from dry grass burnt	3	0.6
9	Explosion of Cooler tank	1	0.2
10	Explosion of generator	1	0.2
11	Explosion of car tire	1	0.2
12	Arson	1	0.2
13	Under Consideration	422	79.5
Total		531	100.0

Source: Metropolitan Fire Brigade

2.4 FIRE-FIGHTING SYSTEM

2.4.1 Fire-fighting Organization

The Disaster Prevention Subdivision, Department of Local Administration, Ministry of Interior takes responsibility for fire fighting as well as other disaster prevention such as flooding and draught in the country. On the other hand, the Metropolitan Fire Brigade Division of the Police Fire Brigade carries out fire fighting activities in the BMA.

In practice, fire fighting activities in local areas are conducted by fire departments under the local administration offices of the Ministry of Interior while the fire fighting in the BMA area is implemented by the Metropolitan Fire Brigade Division with a support by the Disaster Prevention Unit of the BMA that has rescue teams and water trucks.

2.4.2 Fire Fighting Facilities

The Disaster Prevention Subdivision provides fire fighting facilities based on internal regulation which considers standards of the National Fire Protection Association (NFPA) in the USA as the standard reference. A subsidy (20 to 60%) based on the district revenue scale is given from the Ministry of the Interior for the sourcing of equipment. The degree of target achievement of equipment supply is uniformly low, especially in small local government bodies.

In the BMA, the Metropolitan Fire Brigade Division provides facilities based on the modified regulations of NFPA. At present there are 39 fire stations in the BMA, while the regulations require a fire station in each 1.2km sphere. In other words, the current achievement is only 12% of the target. Time of arriving to the site is targeted

at 8 minutes, which was set with reference to other population dense cities in Asia, such as 6 minutes in Hong Kong and 8 minutes in Singapore. However, the actual arrival time is practically still 15minutes.

The degree of achieving targets for fire fighting systems is low both in the BMA and local administrations, but needs depend on the characteristics of a city area. In the local administrations, the further supplement of full-scale fire fighting equipment is necessary. In the BMA, the promotion of distributing fire stations and the reduction of time to arrive at the site needs to be solved.

2.4.3 Other Activities

In addition to the ordinal fire drill, the fire fighting organization carries out the following activities.

(1) Building Inspection:

In accordance with the Fire Prevention and Fire Fighting Act, the Metropolitan Fire Brigade Division inspected 633 hotel, 85 kitchens, and 198 other places in 2000. Total number of the inspections is converted to 2.5 places/day.

(2) Fire Extinguishing Drill Instruction:

The demonstration of fire extinguishing activities and instruction of fire extinguishing are widely conducted. In 2000, the number of dispatch was 300 times and 45,906 persons participated in the demonstration or the drill.

2.5 FIRE INSURANCE

2.5.1 Subscription

The property insurance business had accomplished rapid growth in the economic growth period before the currency crisis. With a nominal base, it has expanded to 3.7 times as many business scale as this from 2,490 million bahts for 1986 to 9,318 million bahts in 1996. The rate of contribution by fire insurance to the property insurance business is falling. The ratio of the fire insurance in the total income of the property insurance business was 40% in 1986 dropping to 15% in 1996 and 17% in 1999.

The admission ratio of fire insurance amongst households is said to be very low. On the other hand, based on the survey of 125 existing buildings, more than 80% of the large-scale buildings, targeted in the Study, have insurance. Out of 26 samples in the household sector, two apartment houses and five shophouses did not have insurance in the household sector. Its admission ratio was estimated at 73%. In the

non-household sector, its admission ratio was counted for 97%. Out of 99 samples in the non-household sector, one hotel and two theaters did not have insurance.

2.5.2 Premium Rate

Department of Insurance, the Ministry of Commerce issues an estimation standard for a premium rate. The standard is invented to determine the premium rate by an evaluation of a hazardous level and fire protection equipment of a building. However, the property insurance industry is, in practice, under excessive competition due to the rapid growth of the economy in 1990's. At present, the premiums for fire insurance are subject to a discounting battle. For setting up the premium, the premium rate, based on various statistics, is not used. The insurance contract is being introduced to the foreign-affiliated firm as reinsurance.

2.5.3 Fire Safety Promotion

The enlightenment activity of fire prevention by the insurance industry and fire prevention safety instruction by the contract insurer, such as is seen notably in the USA, is seldom conducted in Thailand.

CHAPTER THREE:
COMMON PRACTICE OF BUILDING INDUSTRY

3.1 OVERVIEW

3.1.1 Structure and Material

Reinforced concrete (RC) is the most common construction method in Thailand. Residences are also constructed by this method. In the early 1990's, steel structures were introduced for factories and large shopping centers. Shop-houses and low-rise apartment houses are built with post-and-beam structures with the partitions and exterior walls made from concrete blocks and mortar.

In the RC construction, most of buildings are formed by a down-slab method without beams. Their exterior walls are made from concrete blocks with mortar or pre-cast concrete panel with aluminum sashed windows. The partition walls are made from concrete blocks with mortar or walls of light-gauge steel studs and gypsum wallboard. In a steel frame construction, finishing is made from light-gauge steel or gypsum board. The fire proofing covering for steel columns is made of pre-case concrete panel, while covering for beams is made of a vermiculite lightweight cement mortar or painting.

Both in the RC and steel frame construction, the construction methods for ceilings are;

- Steel grid system (suspended ceiling system) with gypsum board, painting and/or wallpaper,
- Plain concrete ceiling and painting,
- Steel grid system (suspended ceiling system), gypsum board, and rock wool acoustic materials.

Floors are finished with carpet in hotels, wood tiles in department stores, and tile carpet with free access floors in office buildings.

Building materials such as iron, cement, aluminum, pre-cast concrete, gypsum board, asbestos, plywood board, etc. are produced in Thailand. Supply of these materials in a market is also easy. Although steel is produced in Thailand, more reasonable pricing is obtained for steel produced from South Korea and East Europe. Since the deforestation in the country has resulted in restrictions on wood supplies, it is imported from Myanmar and Laos. The majority of the production of plywood board is done within Thailand. Autoclaved Lightweight Concrete (ALC) and wall paper are imported.

3.1.2 Fire Protection Equipment

(1) Fire Fighting Control Room

The provision of a fire fighting control room is not required in the Building Control Act and its ministerial regulations, but a fire fighting control room complete with the functions of building facility control and security has been installed in many buildings.

(2) Detection and Report Equipment

The installation of a fire alarm system in high-rise and large-scale buildings is stipulated in the Building Control Act. A typical fire alarm system is to have detectors of smoke or heat type with signal receivers, however, there are some cases of improper design such as the smoke detector installed in front of an air conditioning outlet or shelves for sales products interfering with the detection. In some cases, there is no system to transmit an alarm signal to an external monitoring system.

(3) Initial Fire Extinguishing Equipment

Due to the requirements in the Ministerial Regulation, automatic fire extinguishing systems are installed in many buildings, however, there are some cases of improper design with the sprinklers installed right above the generator making such installations dangerous for fire fighting activities and accelerating fire development. The installation of sprinklers in high stud ceilings has also observed, reducing the effectiveness of the sprinkler to detect and extinguish any fire. Portable fire fighting extinguishers are installed in most of the buildings and can be easily accessed by building users.

(4) Evacuation Facility

In the stipulation related to the safe evacuation of the Building Control Act, there are requirements for electrical systems, such as emergency power supplies, emergency lighting, exit sign illumination, and the smoke control systems by pressurization smoke exhaust. Although a 120 minute emergency power supply is required in the Act, the actual duration of the power supply depends on the building use. For instance, hotels and shopping centers are provided with a generator to allow a 24 hour power supply. With the pressurized smoke control systems, there are problems such as fans with insufficient capacity to supply the correct amount of air, no smoke separation of high-pressurized zones, and low air tightness.

(5) Equipment for Prevention of Fire Spread

In the Building Control Act, there is a description about the installation of fire doors and fire dampers as fire protection equipment for fire spreading. Generally, steel

doors are used for fire doors. However insufficient design of fire doors were observed that it does not fulfill both function of security and evacuation by rational method.

Since the noncombustible filling of penetrated parts by pipes and ducts is not required by the Act, parts of the buildings are imperfect with regards to the prevention of fire spreading.

(6) Fire Fighting Equipment

In the Building Control Act, installation of an elevator for firefighters, and the requirement for an indoor/outdoor fire hydrant are specified. At a department store or a large shopping mall, this equipment is installed as required by the Act. In the large-scale buildings, a fire department hydrant is also usually installed.

3.2 CONSIDERATION FOR EXISTING FIRE PREVENTION SYSTEM

During the Study, the fire prevention systems were evaluated through the on-site inspection and survey on 125 existing buildings. As a result of the survey, large distinctions in the type of fire prevention system among the existing buildings were observed. Besides buildings built with foreign capital or those designed by foreigners with Thai capital, or the buildings designed by Thai sophisticated architects, the other existing buildings dit not generally have sufficient fire preventive measures.

Since the existing buildings were built in accordance with the Building Control Act, the fire preventive measures incorporated have altered as the requirement improved. As mentioned later, the fire preventive requirement has greatly improved after Ministerial Regulation No. 33 was enforced in 1992. The existing building survey has found large distinctions in fire preventive measures between the buildings constructed before 1992 and the ones constructed after 1992.

However, the fire preventive measures in the buildings constructed after 1992 are not strong enough to ensure fire safety. For example, 1) no provision of fire separation and smoke enclosures, 2) improper location and procedures for installation of fire protection equipment, 3) improper materials for pipes and noncombustible fillings at penetrated parts of walls/slabs, 4) use of combustible interior finish materials in large space and evacuation routes, and 5) improper use of the evacuation route, have been encountered. As such, fire will tend to easily spread and it cause difficulty in evacuation.

There are also problems in management and operation patterns. For example, the malfunction of operation panels in a fire fighting control room, the temporary placement of tremendous amount of obstacles in the evacuation route, the closing of

emergency exit with locks, the installation of obstacles such as tables near emergency exits are found in most of the buildings.

CHAPTER FOUR:
REVIEW OF BUILDING CONSTRUCTION SYSTEM

4.1 HUMAN RESOURCES FOR BUILDING INDUSTRY

4.1.1 Educational System

Official qualifications for the Engineer and the Architect are important in the construction field. Completion of an undergraduate course in a university is the minimum requirement to obtain the qualification.

Generally at the university, architecture and engineering knowledge are taught in different departments. In the architecture department, creativity and presentation skill are focused on in the curriculum. Although elementary engineering knowledge is also taught at the architecture department, it cannot usually satisfy the level of basic courses offered by the engineering department. The engineering department has traditionally consisted of three special fields: Civil, Electrical, and Mechanical engineering. Although the departments are more subdivided in recent years, a limited number of schools offer specific fields such as architectural engineering and fire prevention engineering

4.1.2 Qualification System

The recognition of the official qualification for architects and engineers is under the jurisdiction of the Ministry of the Interior. After the amendment of Acts related with the qualification, the authority has widely shifted from a public sector base to a private sector base in 1999 and 2000. The qualification criteria for both architect and engineer are based on similar grant systems. The amendment promoted an effort to establish a Council of Architects for architects and a Council of Engineers for engineers, both of which are independent of the ministry. Both organizations have been given authority to set the requirement for the qualification and issue the qualification.

There are four ranks in the qualification: Senior, Ordinary, Associate, and Special Associate. The ranks depend on the business experience after the graduation from a university. Among these, only architects and engineers, who have fulfilled certain requirements, can sign official documents such as a building permit application.

The number of qualified architects is about 8,000 (7,834), and that of qualified engineers about 120,000. The qualified engineer is subdivided into five classifications: Civil Engineer, Mining Engineer, Mechanical Engineer, Electrical Engineer, and Industrial Engineer.

4.1.3 Associations for Building Industry

The building industry has two major associations: Association of Siamese Architects (ASA) for architects and Engineering Institute of Thailand (EIT) for engineers.

About 8,000 architects have membership of ASA which has published the references for building design and a draft standard of a contract and remuneration. About 2,000 of all ASA members are a new graduates from universities and do not have any official qualification. ASA offers training courses for those members.

EIT has about 20,000 members. It publishes various kinds of technical standards. The EIT standard for each field is utilized as a minimum standard. The contents in the first edition of the fire prevention part the EIT standard were not sufficient to ensure fire safety. However the new edition of the standard has been greatly improved and has been available since the end of July 2002.

EIT has started setting a rank of fire safety for a building, and in addition, it offers training courses to produce persons who can judge the rank. Seminars for training building inspection technicians are also held with an authorization document issued to the successful candidates of the examination. A small number of architects have been also authorized. A Building Fire Inspectors Club (BFIC), which is a voluntary club by the authorized persons, was established as a subsystem of EIT in June 1999.

4.2 CONSTRUCTION PRODUCTION / MANAGEMENT SYSTEM

4.2.1 Stage of Feasibility Study and Building Permissions

In the construction of a large-scale building, a client commits the design work to a design office and usually carries out a Feasibility Study (F/S). In the major companies for development, the in-house staff of the companies carries out the F/S. If the project is judged feasible, the client commits to design offices preparation of necessary design documents and applies for building permission. The design documents include drawings and specifications. The design office, if necessary, orders the work to an engineer office or design freelancers.

In the process of applying for building permission, an application form for business permission, based on the various laws such as the Hotel Act, and the Theater Act, is attached to the application form for building permission. Once a building permission is obtained, the permission can be a target of trade. The permission can be sold and bought by each part of the building use.

4.2.2 Stage for Ordering Construction Work

The detailed design document for the construction order is drawn up in response to the issue of a building permission. The documents including construction

specifications are prepared for the order. In the construction of a large building, a building owner, a management company, and the large-scale tenants are involved in preparing the documents. Those stakeholders usually hire the architects by themselves and modify the design that has received the building permission.

At this stage, engineers prepare design of the building equipment. However, in general they do not prepare the specification of interior finish except when large scale tenants are involved, because the construction is focused on base building body and the main facilities. Although the construction specifications are drawn up based on the EIT standard in many cases, the intent of some clients to reduce remuneration for engineers tends to lead to dissatisfaction of the specifications. Moreover, there is usually no staff who check the conformity between the building plan and building equipment.

4.2.3 Construction Stage

At project implementation, a building owner becomes the client and the owner exchanges a contract with a contractor. In the case of large building construction, the client usually hires a team for supervision (S/V). Since there is no common conditions of contract specifying authority and responsibility for the client, contractor, and S/V team, the authority and responsibility by each party is prepared in the contract documents for each project.

The role of a S/V team depends on timing of the participation to a project. The fundamental role of the team is project management. While managing the schedule of construction works, a S/V team oversees contractors through checking the workmanship of construction and a specification for the construction.

Since there is no official document that is commonly used for technical specifications and the construction standard, so construction progresses based on the requirements stipulated in specification documents drawn up by the engineers. In the successful projects, the documents by each building part such as main building body, outside wall, and each equipment are specific enough to ensure fire safety, however, the contents of specification are technically weak in many other constructions.

In reality, an engineer's technical preference and remuneration influence the contents of specification. The EIT standard is used as a de facto minimum standard. The British and American technical standards are referenced if the need arises. In cases where modifying a specification is necessary during the construction work, the consent of the engineer who prepared the specification is required.

While the prepared design is frequently changed during the construction work, it is rare that the building permission is obtained again from the beginning. Rather, it is usual that the contractors prepare drawings to obtain the building permission with business permission, after the completion of the construction. The S/V team plays a

role of adjusting the construction design in order that the last form of the building conforms to the building control act.

4.2.4 Management Stage

The manager of a building is sometimes the same party as a building owner. A management company manages the building after obtaining the right of management from the building owner for all parts in a simple building, or for a part of a building use in multi-use buildings. There are also instances where the tenant is invited after the commencement of building use. As such, interior finish work is started after completing the main part of the building and obtaining the business permission.

As for fire insurance, it is common for the management company and to add the cost of the insurance premium to the charge to a tenant.

4.3 BUILDING ADMINISTRATION

4.3.1 Organization

The Building Control Committee Board (BCCB) and Office of Building Control Committee Board (OBCCB) were established in the Department of Public Works and Town and Country Planning (DPT) as a central government organization. They mainly work on the legislation of building control. To deliberate any statement of disagreement, the Appeal Committee Board (ACB) and the Office of Appeal Committee Board (OACB) were established.

A local government body works on the issue of a building permission, the implementation of a building inspection, and issues any order for building improvement, based on the act. Typically, staff in the local government body consists of a few staff who have an academic background of structural engineering in the civil engineering and several technicians without any qualification. Only technicians are working at the small local government body levels.

The local government body manages the issue of permissions and inspections at the construction stage or before use is executed, based on the application documents in each action such as new construction, extension and alteration, and demolition, all of which are required in the Act. Structural engineers for civil engineering, or technicians are engaged in the issue and the inspection. However, mechanical, electrical, environmental or plumbing engineers do not work in this area.

After the OACB is asked about a problem actualized in the process of enforcing building inspection, ACB deliberates the problem. In rural areas, the small government bodies ask the large governing bodies for technical advice when required.

4.3.2 Assessment

The main aim of examination and issue of permission is to confirm whether a building design and construction is consistent with the articles specified in the building control act. The staff in charge verifies the calculation method or a calculation value in the light of the act as a part of their work, but the staff is not always in the position to judge building safety.

In the building beyond a specific scale, the signatures by an architect who has legal qualification, structural engineer, mechanical engineer, electrical engineer, and environmental engineer are asked for in preparation of the application form and the construction supervision. It means that safety is judged with the authorization of these experts.

The second revision of the building control act enables the construction work to be started before the issuing of the building permission by the local government body, if provided that architects with official qualification makes design of a building, engineers with official qualification are engaged in the technical design, and engineers supervise the construction work.

4.3.3 Inspection

Staff other than the examination team can carry out the inspection, but in a small government body, staff work on both examination and inspection duties. Some government bodies hire part time staff for inspection duties.

Structural engineers or technicians often work on the inspections, and they confirm whether the building area and the number of floors are consistent with the application document for approval of the building permission, but the aspect of performance for building safety such as the validity of construction of main building body or the installation of equipment is not been examined.

In Thailand, a skeleton lease is usual. The interior finish works are executed after the business permission is issued. The inspection of the building in use is not specified, so, in practice, the edge of fire protection equipment and interior finish material are not covered in the building control administration.

4.4 ACTS AND REGULATIONS RELATED TO BUILDING CONTROL

4.4.1 Related Act

Promulgation of the act and ministerial regulations is initiated by study in the Office of Building Control Committee Board. Then, the Building Control Committee Board drafts up a bill of new act and ministerial regulation which is subjected to an approval by the minister. After the approval, the draft of the act is issued to the

Parliament, while ministerial regulation is sent to the Cabinet. At the final stage, the draft of new codes is submitted to the Council of State for its consideration and approval, and the new codes are enforced by an issuance of the Government Gazette from the council.

In addition to the Building Control Act (BCA), there is the Town and Country Planning Act, and the Promoting and Controlling the Quality of Environment Act, both of which control each areas of building construction. They also provide restrictions for grouping with zoning control.

There are various kinds of laws such as the Fire Prevention and Fire Fighting Act, the Fuel Act, Fuel Control Act, the Factory Act, and the Labor Protection Act, all of which are relevant to the fire safety of building. These stipulations focus on the treatment of hazardous materials and partially on fire protection equipment. However, the stipulations for fire protection equipment are not broadly described.

For the acts restricting to buildings in use, there are various acts such as the Hotel Act, the Condominium Act, and the Factory Act. In these acts, periodical reports about management and continuation of the target project are required, however, no stipulation for the physical condition of buildings is prepared.

Table 4.1: Classification of Laws related to Building by Objectives

Classification	Name of Laws
1) Laws aiming at proper performance of a building (in terms of fire prevention and safety)	• Building Control Act • Fuel Control Act • Fuel Storage Act • Liquefied Petroleum Gas Containing Act • Fire Prevention and Fire Fighting Act • Fuel Act • Public Health Act • Labor Protection Act
2) Laws aiming at proper use and/or shape of a building in a designated area	• Building Control Act • Town and Country Planning Act • Air Navigation Act • Promoting and Controlling the Quality of Environment Act
3) Laws aiming at proper performance of building for its operation in a specific usage	• Condominium Act • Entertainment Act • Hotel Act • Factory Act • Hospital Act • Dormitory Acxt

Source: JICA Study Team

4.4.2 Composition of Building Control Act

The building codes consist of the Building Control Act and Ministerial Regulation (MR). Moreover, based on the Act, a local government body can provide a By-law.

The act focuses on an executive organization and execution procedure. It covers the application of building permission and building inspection. All technical requirements are defined in the ministerial regulation, which covers the form of various procedures, the items limited to areas, and the technical requirements. Fifty eight kinds of ministerial regulations are enforced with other further drafts of the regulation by the BCCB being deliberated now.

Since a ministerial regulation is published in response to a social request, it does not have composition by technical classification, such as structure and fire prevention. In accordance with the appearances of a high-rise building and large-scale construction, the stipulations are newly added. Although reference of a specific standard document is not stipulated at all in technical items, the stipulation asks for the signature of the architects or engineers who have a official qualification. The ministerial regulation indirectly references to the EIT standard.

At present, the By-law of the BMA is the only By-law in Thailand. The By-law was enforced at the same time as the Building Control Act in 1979. A new By-law, in which the contents are improved, was legislated in the year 2000.

Table 4.2: Existing Ministerial Regulations under the Building Control Act (1/2)

No	Year	Subject	Main Field					
			PRC	ARE	CST	FPR	EQP	SHP
1	1981	Conditions of Inspector and Engineer	○					
2		Identification Cards for Inspector and Engineer	○					
3	1983	Measures against the buildings violating the regulation	○					
4		Safety measures for construction work on special buildings.			○	○		
5	1984	Buildings required to get permission before start using or operation	○					
6		Structural strength of building. Allowable stress of materials.			○			
7	1985	Fee for building permission	○					
8		Forms for building permission application	○					
9		Exemption of application of regulation	○					
10		Application forms & attached drawings and documents	○					
11		Standard of modification and demolition				○		
12		Standard of building construction, modification, demolition and moving which is not in accordance with the permitted layout.				○		
13		Prohibited areas from constructing and modifying buildings or changing building purpose in Ayudya province						○
14	1986	Revision of Clause 9 in MR No.9	○					
15		Building restriction in Phuket Province		○				
16	1987	Building restriction in Bhuddha Monthon area in Nakhon Pathom Province		○				
17		Building restriction in Samtprakarn Province		○				
18		Addition to MR No. 4 (escape way for building construction sites, etc)				○		
19	1988	Building restriction in Songkhla Province		○				
20	1989	Building restriction in Phuket Province (other than MR No. 15)		○				
21		Empowering MR18						
22		Building restriction in Surat Thani Province		○				
23		Signboard Installation						
24	1990	Building restriction in Nonthaburi Province		○				
25		Building restriction in Nonthaburi Province		○				
26	1991	Building restriction in Ayuthaya area		○				
27		Building restriction in Supanburi Province						○
28		Building restriction in Chiangmai province						○
29		Application forms & attached drawings and documents (add. To MR10)	○					
30		Building restriction in Petchaburi province						○
31		Building restriction in Chantaburi province						○
32		Building restriction in Cholburi province						○

Source: JICA Study Team

Table 4.2: Existing Ministerial Regulations under the Building Control Act (2/2)

No	Year	Subject	Target Field					
			PRC	ARE	CST	FPR	EQP	SHP
33	1992	Regulation for building equipment of high-rise or extra-large buildings				○	○	
34		Building restriction in Nakornnayok province						○
35		Building restriction in Satul province						○
36		Building restriction in Prachuabkirikhan						○
37		Building restriction in Samutprakarn province						○
38		Delegation to local officials to order correction	○					
39	1994	Fire prevention equipment and service facilities for low or middle high rise buildings				○	○	
40		Building restriction in Cholburi province						○
41		Parking lots or mechanical parking system						○
42		Fire prevention equipment for or mechanical parking system				○	○	
43		Revision of MR No. 26 (building restriction in Ayuthaya area)		○				
44	1995	Regulation on drainage facility					○	
45		Amendment to MR 10 (Simplification if application forms for small houses etc)	○					
44	1995	Regulation on drainage facility					○	
45		Amendment to MR 10 (Simplification if application forms for small houses etc)	○					
46	1997	Building restriction in Pathumthani Province and Nonthaburi Province		○				
47		Amendment on MR38 (Order for correction on existing high-rise buildings etc. that have problems on safety)	○					
48		Amendment on MR6 (Regulation on fire resistant construction)				○		
49		A seismic design regulation in Northern and Western region			○			
50		Amendment on MR33 (Open space around the buildings, open space ratio, floor area ratio for high-rise buildings etc.)						○
51		Revision of MR No.44 (regulation on drainage facility)					○	
52		Addition to MR. No.28 (Building restriction in Chainmai area)		○				
53		Building restriction in Chashensao area		○				
54		Building restriction in Ayuthaya area		○				
55	2000	Regulation on each part of general buildings, and regulation on space around and with buildings or height restriction according to the width of the road, etc			○			○
56	2000	Amendment on MR10 (Attachments for building permission)	○					
57	2001	Effective period and renewal of building permission	○					
58	2001	Objective buildings of BCA	○					

Source: JICA Study Team

Note:

1) PRC: Legal procedure, ARE: Area restriction, CST: Requirements for construction, FPR: Requirements for fire prevention, EQP: Requirements for building equipment, and SHP: Requirements for height, open spaces and control of buildings.
2) After the legislation of Ministerial Regulation No. 57, the title of subsequent MRs ceases lining up by numerical order.
3) The subject and target field of each MR in the table are assumed by the JICA Study Team.

4.4.3 Contents of Ministerial Regulations for Fire Prevention

Requirements for fire prevention are specified in the seven ministerial regulations as shown below.

Ministerial Regulation No. 6 (1984) :	Requirements of the fire codes for the special building during progressing construction.
Ministerial Regulation No. 33 (1992) :	Requirements of many fire codes for high-rise and special large buildings including fire resistant materials, evacuation, support of fire fighting and rescue, and fire protection equipment.
Ministerial Regulation No.39 (1994) :	Requirements for installing fire preventive equipment in middle and low-rise buildings.
Ministerial Regulation No.47 (1997) :	Requirements for improvement of existing buildings, to specify provision of escape stairways, installation of portable fire extinguishers and fire alarms, and the installation of emergency lighting for high-rise/large scale/special use buildings.
Ministerial Regulation No.48 (1997) :	Requirement of using fire resistant materials for the main structure of special use buildings, after the experience of a factory fire.
Ministerial Regulation No.50 (2000) :	Requirement of installing equipment at high-rise and extra-large buildings as a revision of No.33.
Ministerial Regulation No.55 (2000) :	Requirement of providing fire resistant walls to low-rise buildings and the introduction of codes for provision of escape stairways, interval between adjacent buildings, and evacuation routes outside a building

By enforcing these codes, the contents of the codes for fire prevention have been largely improved over the last 10 years, however, fire preventive performance, which should have been incorporated into large-scale, high-rise, and multi-use buildings in the second construction boom has not been properly done. Fire prevention specified in the existing codes and of existing buildings is discussed in details in the Part II of the this report. The following items are the main problems in the current codes.

1) In some areas, basic fire preventive measures such as fire separation, smoke enclosure, use of noncombustible interior finishes are not introduced.

2) There are some requirements which specify excessive fire prevention performance. For instance, 3-hour fire-resistance rating are uniformly specified for special use buildings without relation to the scale of buildings. Installation of automatic sprinkler systems is required for any part of high-rise and extra-large buildings. There is no requirement to exclude from the installation the parts of

which characteristics are not suitable for the automatic sprinkler systems.

3) There are no stipulation of the procedure and measure that ensure a fire safety of innovative materials, assembled parts, and special buildings which are not adequately assumed and/or covered by the ministerial regulations.

4.4.4 Testing and Evaluation Systems for Building Materials and Assembled Parts

Standard methods for fire testing are specified in the Thai Industrial Standard (TIS) issued by the Thai Industrial Standard Institute under the Ministry of Industry. The testing standard is directly introduced from the ISO standards and published in the 1996 Catalog, the latest version, with the following eight items.

- TIS 1334 Fire-resistance Test - Elements of Building Construction
- TIS 1335 Fire-resistance Test - Door and Shutter Assemblies
- TIS 1336 Fire-resistance Test - Glazed Elements
- TIS 1337 Fire-resistance Test - Ventilation Ducts
- TIS 1338 Fire Tests - Building Materials - Non-combustibility Test
- TIS 1339 Fire Tests - Building Materials - Determination of Calorific Potential
- TIS 1340 Fire Tests - Reaction to Fire - Ignitability of Building Products
- TIS 1341 Par 1 Fire Tests - Evaluation of Performance of Smoke Control Assemblies - Part 1 Ambient Temperature Test

The Ministry of Industry has established the Office for National Accreditation Council (ONAC) which has responsibility for approval and registration of testing organizations in accordance with ISO 17025. However there is no organization for testing of building materials registered by the ONAC.

In Thailand, there is no fire testing equipment other than two furnaces owned by the Chulalongkorn university. They consist of a vertical type (heating plane: 2.5 m x 2.5 m) for walls/doors/shutters and horizontal type (heating plane: 3 m x 3m) for floors/beams/columns and operate in accordance with ISO 834 ‘Fire-resistance Tests - Elements of Building Construction’.

Regulation MR 48 specifies “Reliable Institute” for carrying out testing of fire-resistance structure. At present, there is no designated testing organization for the reliable institute. Since the ISO standards specify testing specimens for fire-resistance tests of 3 m x 3 m for vertical types and 4 m x 6 m for horizontal types, the furnaces of the Chulalongkorn university do not meet with requirements of the ISO and TIS. The furnaces also needs improvement by installation of loading devices and thermocouple apparatus.

To this end, requirements of the building control act are not supported by technical evaluation systems which make a judgement for the appropriateness of building materials.

CHAPTER FIVE:
IDENTIFICATION OF PROBLEMS

5.1 PROBLEM STRUCTURE

Based on the review of the current conditions, problems were identified by using a problem tree showing the cause and effect of the problems (Figure 5.1). It should be noted that many of these problems originated in the low attention and awareness of fire safety by non-technical people as well as those specialists in charge of the design and construction of buildings.

This situation might be attributed to the fact that a relatively small number of large building fires have occurred in Thailand to date, as large-scale and high-rise buildings are rather new to Thailand, and these buildings are not yet reached the age of frequent fire risk. For example, in Japan, a fire generally begins to break out in buildings which are 14 to 15 years old. In Thailand, on the other hand, it is in the 90's, or in the second construction boom, that many large-scale buildings were built which may lead to a large calamity in case of fire. The large-scale buildings in Thailand are still around 5 to 10 years old after the construction.

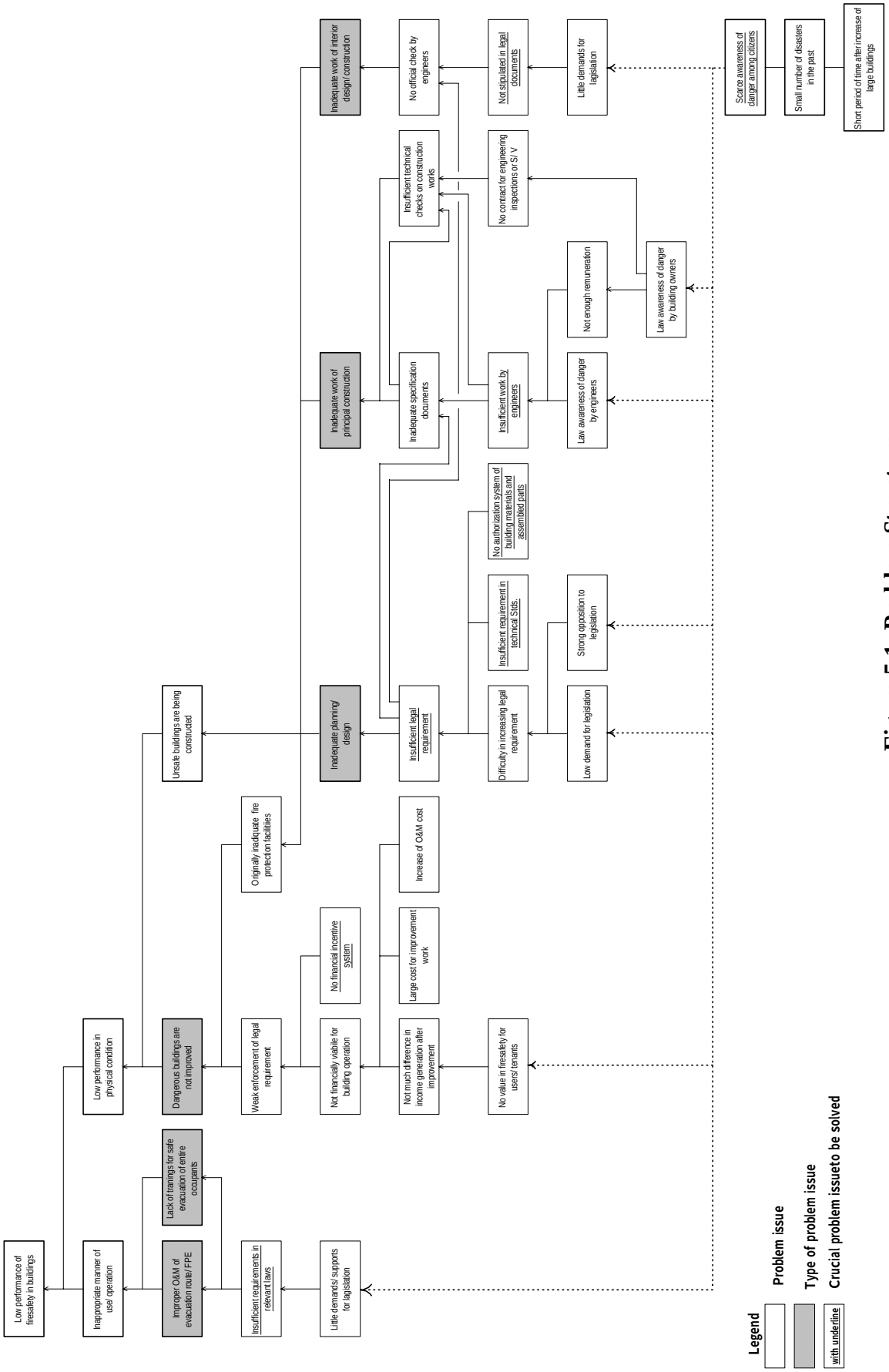


Figure 5.1: Problem Structure

5.2 ANALYSIS OF MAJOR PROBLEMS

All the problem identified in the above problem tree can be consolidated to the following six points.

(1) Insufficient Building Design for Fire Prevention

In Thailand, the Building Control Act has legal force to all parties and the EIT standards are functioning substantially as a minimum standard for all registered engineers. Therefore, it can be safe to say that the design works are undertaken based on these two documents. However, the requirements stated in these documents are insufficient when compared to the objectives to attain the desired level of fire safety performance for those buildings set as the target buildings of the Study.

Although there are many examples where architects and/or engineers refer to the standards of foreign countries, there is still reliance on the sincerity and subjective judgement of individuals.

In addition, it is hard for a designer to get an understanding from a building owner as a design which asks for a higher fire safety performance will inevitably call for the reduction of effective (rentable) areas, increase of initial investment cost, and increase of maintenance expenses.

(2) Inappropriate Construction Works

In Thailand, engineers having prepared design of a building have to take responsibility to secure the appropriateness of construction works of the building. As a general practice, engineers prepare the technical specification documents and the construction works are carried out based on the prepared specification documents, especially in the case of projects with large scales.

However, the technical specification documents are not always well prepared as it is not clearly mentioned in the legal documents to secure the appropriateness of the specification documents. In addition, since inspection and construction supervision by engineers is not clearly required in the legal requirements as well, it is influenced by the contents of contract with the project owner. As such, the correct inspection and supervision by engineers are not always implemented.

(3) Uncontrolled Interior Finishing Works

In Thailand, it is considered that the completion of construction work is defined at the time when the major structure is built, or more often called the “skeleton”. Then the permission of use can be distributed at this stage and, in general, building owners start inviting tenants and interior finishing works are carried out. It is at this stage where the selection of noncombustible/quasi-noncombustible materials is made and

the final installation of the main fire-extinguishing equipment such as a sprinkler heads, indoor fire hydrant, and portable fire extinguishers, are carried out

There is no clear requirement in the Building Control Act concerning the design/construction of interior finishing works. In addition, it is not included in the subjects for checking/permission by the building administration.

(4) Scarce Progress in Improvement of Existing Buildings

Legal controls on fire prevention were introduced whenever needs arose in the 1990's. As a result, many buildings constructed before the enforcement of each ministerial regulation are now no longer consistent with the current legal requirements. To cope with this, MR 47 was issued and the installation of lightning protection and improvement of six items are required to existing buildings inconsistent to the current requirements.

However, the required items in MR 47 are insufficient for some buildings. In addition, it is difficult for the local governments to apply legal enforcement, although they have the right to issue orders to the building owners of existing buildings to upgrade to the requirements of the MR 47.

Enforcing the controls in MR 47 significantly influences the financial status to building owners and operators. In general, improvement works require not only the cost of design, and construction, but also calls for an increase in running cost for additional equipment and a decrease by suspension of business. Plus, due to the low consciousness about fire risk among the people, the income of buildings with high risk of fire is almost equal to the less risky ones. Moreover, no preferential financing measures are established in terms of fire safety. Therefore, the financial burden for the building owner/operator will be high after the improvement and it is hard for the local government to get agreement of owner/operator.

(5) Improper Operation and Maintenance of Fire Protection Equipment

General fire protection equipment are required in the existing ministerial regulations. However the installed fire protection equipment are not always properly operated and managed to fulfill the expected functions. The operation and maintenance of this equipment is not required under the Building Control Act. In addition, clear stipulations for the maintenance of the equipment is also not provided in the Fire Prevention and Fire Fighting Act or other pertinent acts

Although there is a provision which imposes a duty to check equipment in the current EIT standard, it is difficult to implement since it does not impose any legal force on the building owner.

(6) Improper Manner of Use and Operation

Although, among the fire related laws and regulations, there are some statements that provide requirements to check the conditions of buildings in use, these are limited to the regulation on the handling of dangerous objects and are not concerned with the suitable maintenance and reservation of evacuation routes.

Moreover, although a duty of the fire drill to an employee is imposed by the Labor Protection Law, it does not encompass the safe evacuation of the users/visitors of a building but the corresponding employees themselves.

5.3 ON GOING EFFORTS AND THEIR LIMITATIONS

5.3.1 Revision of the EIT Standard

In the new edition of the EIT Standard for fire prevention, the contents had been largely improved and expanded. This standard was published in the end of July 2002 during the Study. In this new edition, the main items on fire prevention were mostly covered, including the introduction of fire prevention techniques, which were missing in the previous edition.

Although there is no reference duty provided by any legal documents, the EIT standards are functioning as the minimum standard for most of the registered engineers, and therefore it can be utilized in the technical design works and construction supervision for many buildings, and will induce a significant improvement.

However, as it is by nature of an EIT standard having obligation for the engineers to be referred, there are limitations to its power to cover the entire building construction. Major issues are as follows.

(1) No Assurance to be Referred by Architects

The EIT standard requires fire separation, evacuation routes, and interior finish control, which are the items that are considered in the process of architectural design and/or interior design executed by architects. The standard might be useful for engineer’s recommendations to architects to address the above items, but it cannot be a minimum standard in architectural design and interior design, because there is no legal responsibility for architects to refer to it.

(2) No Assurance of Engineers’ Involvement

In order for the EIT standard to be referred to by engineers, there is a requisite that the engineer is participating in the design works and construction supervision through a contract from the project owner.

However, it is not a duty for the project owners to employ engineers for the preparation of specification documents, inspection during construction, or supervision of construction works. Therefore, it is not necessarily followed that the EIT standard will be referred to at the design and/or construction of *skeletons*, as well as the interior finishing works.

5.3.2 Enforcement of a New Ministerial Regulation

In the ministerial regulation being deliberated now, a duty for the periodic inspection and evaluation of a building in use will be imposed, along with the implementation of an inspector's qualification system, creation of periodic inspection reports, preparation of maintenance management plan of equipment, and fire drills aiming at a building user's safety etc.

This will provide meaningful effect, since it enables the building administration to control the buildings after the completion of the main structure construction, which previously has not been substantially regulated. Improper installation and maintenance of equipment will be pointed out by an inspection team consisting of specialists, who will also be established by the new ministerial regulation. The required improvement measures will be submitted to the building owner/operator. This is judged to be very effective and efficient to the improvement of existing buildings which are built before the enforcement of the new ministerial regulation.

However, since there are no regulations on the stage of interior finishing, the same improvement measures will be called for in the newly constructed buildings including the ones to be constructed after the promulgation of the new regulation. In other words, unless the proper interior finishing work is secured beforehand, it will lead to the asking for rework in a short period of time after the original work, which could result in a financial loss to many parties.

CHAPTER SIX:
BUILDING FIRE SAFETY SYSTEM DEVELOPMENT STRATEGY

6.1 GENERAL DIRECTIONS

Compared to many foreign countries, a big fire is rather rare in Thailand. However, in past big fires, over 100 lives were lost in a single case. From the results of the existing building investigation, it was established that many buildings were in the same physical and/or social condition to those buildings which had suffered from the calamity in the past. Since it is expected that the rate of an outbreak of fire in large-scale buildings will increase in Thailand as mentioned before, it is not deniable to say that the potential danger for a large fire calamity is high in Thailand.

Therefore, it is necessary to prevent such danger as much as possible. Taking the socio-economic situation, administration systems, and the current building production system into consideration, the basic directions for the building safety system development will be the three items as follows:

(1) Strong Government Initiative

Since the risk of a big building fire is not yet apparent, there is still a weak consciousness of building fire safety in the society of Thailand. Under this circumstance, it is hard to expect that the improvement of building fire safety will be attained by the private sector alone, through the market mechanism, since fire safety is not perceived as an economic value. Therefore, it is necessary for the government sector to decisively initiate the task for protecting safety for the public.

(2) Cooperation with Private Experts

While positive measures by the government sector is called for, the expansion of a considerable amount of work is expected by the government staff in charge. It is not realistic to recruit new staff with specialties in this field due to the scarcity of human resources in this sector. Besides, efficient management of the government sector is strongly called for in the 9th National Economic and Social Development Plan, which was put in practice from October 2001.

In the building control system in Thailand, there is a momentum to transfer the responsibility to private sector specialists, putting the basis on the laws and regulations stipulating the professionals, namely the Engineer Act and the Architect Act. Based on such a background, it is realistic and effective to make the best use of private sector experts for the establishment of the fire safety system.

(3) Promotion of Forming the Society which accepts Fire Safety to be Economic Value

As a secondary effect of the government sector initiative to result in reduction of fire losses, the conciseness for building fire safety will likely to be left at the current weak level in the society. As a result, it is unlikely that a market oriented efficient achievement will be performed.

In order to prevent such a situation, it is necessary to promote the formation of a society which accepts fire prevention safety to be an economic value and simultaneously, development of a building fire safety system based on the same roots.

6.2 DEVELOPMENT TARGETS AND CONCEPT FOR FIRE SAFETY LEVEL

The ultimate fire safety performance means that safety of lives and properties are secured so as to prevent them from any damage by fires. On the other hand, the property safety needs to prevent outbreak of fire and extinguish the fire broken out. To achieve this, fire extinguishing require adequate force of fire fighting and support by infrastrcture which provide water resource for fire fighting. However fire fighting equipment in Thailand is not prepared to the level targeted by the country, it may take long time to provide adequate equipment. Therefore, safety level targeted by the building fire safety system should focus on securing life safety.

Based on the general directions stated above, the following three points are recommended as the broad targets, which should be implemented with a high urgency to develop of the building fire safety systems for securing life safety in Thailand:

(1) Securing of the new buildings to be constructed,

(2) Improvement of the existing buildings, and

(3) Improvement of the manner of use/operation in a building.

6.3 RECOMMENDED PROJECTS/PROGRAMS

The projects/programs are recommended to realize the development targets, which may applicable to Thailand. These have been arranged, based on the character of works, and can be divided into six fields. A brief description is as follows.

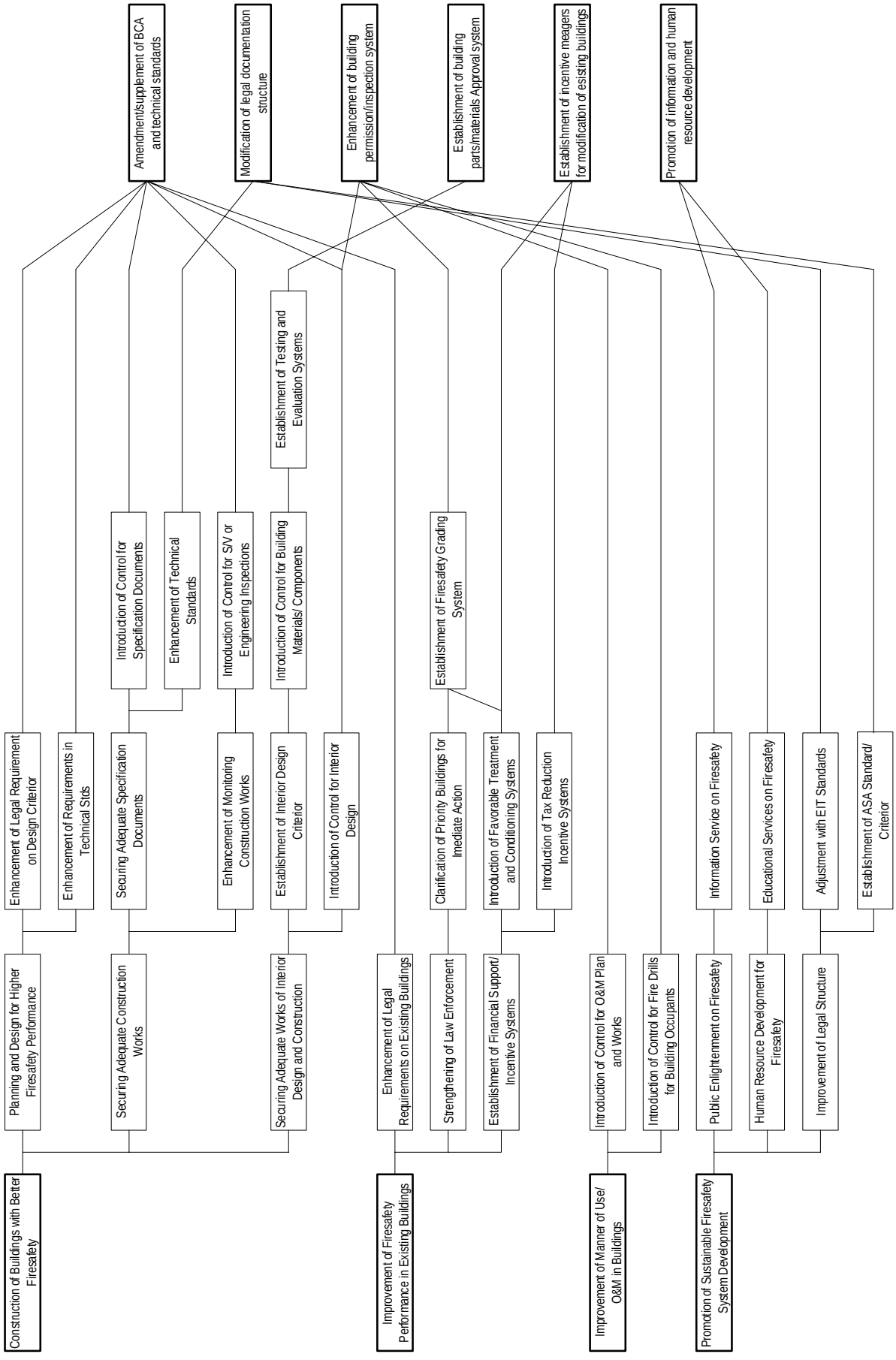


Figure 6.1 : Projects/Programs for Development Targets

6.3.1 Expansion of Technical Regulation and Standard for Building Fire Safety

The technical requirements of the ministerial regulations and the EIT standard should be expanded as soon as possible. Recommendation for the expansion of requirements focus on necessary technologies for life safety. This is extensively discussed in Part III of this report.

6.3.2 Reorganization and Expansion of the Related Documents

After the promulgation of the second revision of the Building Control Act, judgement of building safety has been entrusted to the registered professional architect and engineer for a certain extent. Responding to this, the revision of the Engineer Act (1999) and Architect Act (2000) followed, and a system to secure a proper level of work for these specialists is being developed.

Under these circumstances, the Building Control Act, along with its ministerial regulations, and the EIT standard are the major two documents which stipulate requirements on building fire safety. Although the positioning and the role of these documents are different, it would be desirable if they were closely cooperated and mutually complemented. However, currently there are several statements which are not suitable within the position and role of the documents. Also, there are some descriptions which should be adjusted in reference to each other.

In order to solve the situation, it is necessary to change the structure of these documents following deliberation among the concerned organizations. Specifically, the Building Control Act has legal power to all persons concerned including the building owners, while the EIT standard has effect only to the engineers who are involved in a building project through a formal contract. Since it is limited to the Building Control Act, which can have effect to an architect, it is realistic to stipulate the requirements on architectural planning and interior design in a ministerial regulation under the Building Control Act, for the time being. In the future, it is desired to formulate an ASA standard (tentative name) as a minimum standard which will cover the architectural planning and interior design and can be referred to by all the registered architects.

In short, the future structure of fire codes should be formed by three documents, namely; the Building Control Act and its regulations, the ASA standard (tentative name), and the EIT standard. The role of these documents are mentioned below.

(1) The Building Control Act and its Ministerial Regulations

As mentioned above, the Building Control Act is a document which has legal effect to all persons concerned, including the project owner. By using this status, it can provide the legal ground for the semi-compulsory reference of the EIT standard and the ASA standard (tentative name) by properly requiring the inspection by architect

and engineers to clients based on a contract. It is recommended to specify signature of a registered architect/engineer at the crucial stages of the building construction project.

A certain amount of time will be required for the preparation of the ASA standard (tentative name). Therefore, fire prevention techniques with high urgency, such as evacuation planning and fire/smoke compartmentalization, need to be stipulated in the ministerial regulations, which architects have to refer to, for the time being.

When the three documents system is established in the future, the Act should shift the manner of the statements to a character of performance based code as much as possible, while the EIT and ASA standards provide technical solutions for the legal requirements. By doing so, the continuous development of the field of building construction technology will be better secured.

(2) The ASA standard (tentative)

As pointed out earlier, there is a limitation in the effect of the EIT standard to architects, although it covers many aspects of building fire safety techniques extending into the architects' field of work. There needs to be a document which shows standards for planning of fire safety measures and that can be referred to by the registered architects, especially with regard to fire compartmentalization, smoke compartmentalization, evacuation planning, and interior design.

At this time, ASA has not published a standard which describe the minimum requirements in architectural planning, or interior design that will cover crucial parts of building fire safety. As the architectural planning includes crucial parts for building fire safety such as securing adequate evacuation route and fire separation to prevent fire spread through horizontal and vertical openings, therefore it is desirable to issue standards which will be referred to by architects and basis for architects to take responsibility for their designs.

The most certain and quick solution is to provide a specification based code by a ministerial regulation. In the future, an ASA standard should be published as a minimum standard to cover various techniques to meet the requirements described in the ministerial regulations as the performance based code.

It should be noted that, since the organization of ASA is small, it is necessary to expect a certain amount of time for the issuing of such a standard. There may also need to be governmental support with respect to funding and the provision of necessary personnel.

(3) The EIT standard

The EIT is making significant efforts to expand contents of its standards in various fields of engineering, and in the new EIT standard's fire prevention edition, many of the required measures are covered for building fire prevention.

In the future, it is desirable to carry out revision of the standard, after adjusting for the ministerial regulations and the ASA standard. The EIT standard should devote its role to that of a technical standard, which shows by what and how the required performance, given by the architectural plan based on the ministerial regulation and the ASA standard (tentative name) is achieved.

6.3.3 Expansion of Permission / Inspection System

(1) Obligation of the Periodic Inspection and Report of a Building in Use (enforcement of the new ministerial regulation)

The building administration should strengthen building control to the building in use as there are many cases of improper interior finishing and the incorrect installation and maintenance of fire protection equipment observed. For this, a new ministerial regulation is under deliberation as mentioned earlier, and when it is promulgated, this need will be achieved. The new ministerial regulation strengthens periodic inspection/report on existing buildings by its requirement and early promulgation is desired.

(2) Obligation of Technical Inspection/ Supervision

It is desirable that at the time of the main structure construction as well as the interior finishing works, the inspections and/or supervision should be carried out by engineers through the formal contract. As a legal power is required to force the project owners and promulgation of a new regulation or amendment of the Building Control Act will be required for this to eventuate

As for the requirements in the Act, it is desirable to force the project owners to submit proper documents with signatures of relevant engineers to the building administration office in a construction stage.

However, this could lead to superfluous requirements in the cases of small-scale buildings such as detached housing, or where engineers are separately employed for construction supervision. Therefore the type of buildings, it applies to, must be clearly defined, based on type of use, scale (spatial layout and floor area), and height (or the number of stories). Also, a selection for a building owner should be involved in the requirements to choose either employment of S/V team or inspection by registered engineers who will submit an inspection report with their signature.

(3) Introduction of the Permission System for Interior Finishing

Since the interior is the element greatly concerned with building safety against fire accidents, especially in the initial stage, it is vital that control and supervision is introduced. This is especially true in Thailand because much of the essential fire protection equipment, such as fire alarm and fire extinguishing systems, tends to be installed at the interior finishing work stage. It is desirable that an interior finishing plan should be submitted to the building administration office with a document on which signature of architects and engineers are made based on the requirements in the Building Control Act.

6.3.4 Establishment of the Authorization System of Building Materials and Assembled Parts

In order to raise the fire safety level of a building, it is vital to define the fireproofing performance for building materials and assembled parts. Therefore, it is a prerequisite that a certain grade of fire resistance is secured for the materials and parts available in the market. Currently, an authorization system for these materials and parts is not established in Thailand. Therefore, when the fire codes are upgraded, there is a possibility that the domestic products, which are available with the cheapest price in Thailand, will not be able to be used for construction.

Avoiding the situation mentioned above, it is necessary to establish an authorization system for building material and assembled parts as soon as possible for improvement of the regulations and technical standards. This effort needs to form a system which provides a directory of authorized materials and assembled parts with easy access to users.

In Thailand, the Ministry of Industry is the organization which enacts the "Thai Industrial Standard" (TIS), and has defined a total of eight kinds of methods for the fire testing complying with the ISO standards. However, there is no organization that has the fire testing equipment necessary for carrying out these testing tests.

Similarly the Office for National Accreditation Council (ONAC) has been established under the Ministry of Industry and it has already registered many testing laboratories based on requirements of ISO17025 ‘General Requirements for the Competence of Calibration and Testing Laboratories’, but there are no registrations for fire testing laboratories.

Thus, the establishment of the authorization system needs to start from the very first step. The authorization system for building materials and assembled parts consists of three major activities, namely: testing, evaluation, and authorization. Each of these should be developed through a phased approach as described below.

(1) Establishment of Testing Organizations

A testing organization carries out fire testing works based on a specified testing method and publishes the test results reports. The recommended phased development approach is as follows.

In the first phase, the DPT formulates criteria to approve and designate testing laboratories which can properly carry out the testing works. The criteria should be formulated to the requirements of ISO17025 as testing laboratories will need to apply for the registration by the Ministry of Industry in the future. Moreover, some satellite testing laboratories should be appointed in major regional center cities, such as Chain Mai, Khon Kaen, and Had Yai.

In the second phase, the testing laboratories authorized by the Ministry of Interior should obtain the accreditation of the Ministry of Industry, after accumulating a certain level of experience and capacity.

In the third phase, it is necessary to establish international recognition of the testing results documents by bilateral and/or multinational basis, utilizing the fact that the Thai Industrial Standard Institute (TISI) is an 'Asian Pacific Laboratory Accrediation Cooperation' (APLAC) affiliation organization representing Thailand. By this stage, the testing organizations of Thailand would be accepted both domestically and internationally. This results in the possibility to allow international distribution of building materials and products upon mutual approval.

The existing Ministerial Regulation No. 48 specifies 'ASTM E 119 Standard Test Methods for Fire Tests of Building Construction and Materials' as the testing standard of fire resistant construction. Every national standard is made to reflect backgrounds of socio-economic conditions and technology in the country. Therefore, taking into consideration the current of international harmonization of the standards in recent years and the international distribution of materials and products in the future, the testing standards are required to be independently formulated in Thailand with the conformity to the ISO standards which the TIS standards follow.

(2) Establishment of Evaluation System

An evaluation organization or committee will carry out a technical evaluation on the testing result reports published by the approved testing organization, and then publish a technical evaluation certificate. The establishment of an evaluation organization will also require the phased approach for development.

In the first phase, it is required to establish two or more evaluation committees under DPT and to prepare the valuation criteria for building materials and products, before establishing a complete evaluation organization. For the time being, the organization/committee should deal with three items; fire-resistant structure, fire protection equipment, and fire proofing materials.

In the second phase, a technical evaluation organization should be established, when a valuation criteria is ready and the potential capacity of the organization has come to be sufficient. Similar to the case of the testing organization, the task should be performed based on criteria that are consistent with internationally accepted standards such as 'ISO17065 General Requirements for Bodies Operation Product Certification System'

In the third phase, it is desirable to align with the international momentum to realize multilateral recognition of the evaluation document, which is not limited to the testing results but extends to documents published by an affiliate evaluation organization. By successfully doing this, the evaluation system will be improved in a sustainable manner, and opportunities for the export of Thai product will also increase. The 'World Federation of Technical Assessment Organizations' (WFTAO) would be a good candidate to join for this purpose.

(3) Establishment of Authorization Organization

The authorization is a legal action by the government body. The authorization organization will check and register the evaluation procedure of the technical evaluation documents and promote publication of a directory for building materials and assembled parts by directly issuing or providing editorial supervision to the ones who publish the document.

The improvement of building safety will be achieved whenever the building codes regulate the usage of approved materials; products, and systems, and where those approved building components are published by technical directions, the information of technology is widely and impartially distributed to architects/ building engineers/ contractors/ building owners. These activities also promote modernization of building construction process and formulation of preferable building stocks.

The authorization is considered as a part of service activities in a legal status. There may be two ways to formulate an authorization organization; 1) a direct operation by the government by setting up a new division in a government office in charge of building administration (the Building Inspection Bureau), and 2) a separate organization to be established by the designation of the government. For the time being, taking into consideration current capability and system of administration as well as human resources in a private sector in Thailand, it is more realistic to employ the former approach, but the future organization could be an independent one responding to the accumulation of human resource and increase of demand in the society.

6.3.5 Establishment of Financial Incentive Systems

Although the existing buildings have a high risk of fire, improvement works has not been sufficiently implemented. Since there are a huge number of existing buildings

with the potential of higher fire risk, it is not realistic that the government superintends and guides them all. Besides, it is difficult to strengthen the law enforcement unless the society becomes sensitive to the fire risk of buildings. Thus it is necessary to formulate an environment where the improvement of the existing buildings progress by the building owner's spontaneous intention as much as possible.

In order to form such environment, there should be focus on the financial aspects in terms of building operation and management. In respect to the income side, it will take some time for the ordinary building users to become sensitive to the fire prevention of a building, that may lead to the reduction of the profitability of the building owner/operator. In respect to the expenditure side, it is possible to produce a certain amount of effect by the cooperative efforts with relevant organizations such as taxation offices and financial institutions with practical target periods. A brief explanation follows.

(1) Preferential Taxation System

It is effective to provide a difference in the tax rates between a disqualified building and a building after improvement, after providing the regulation stipulating the periodic inspection of buildings in use. Therefore cooperation with the taxation authorities should be initiated as soon as possible. Formation of the tax-rates system should be interlocked with the fire safety grading system classified into three fire safety levels, which are to be introduced by the new ministerial regulation.

(2) Preferential Insurance Rate System

The fire insurance industry in Thailand is under excessive competition, and the firms are providing superfluous price-reductions. Therefore, it will require some time before the industry becomes sophisticated to the level that the preferential rating system becomes to be common as presented in developed countries. However, it should be pointed out that the present excessive competition is beyond the healthy range. Moreover, it will be too late if the government keeps a wait and see policy until the streamlining of the industry is forced to take place through many building fires.

Since the grading of the building fire safety mentioned above will help to reduce assessment cost of the insurance firms, the cooperation is likely to be welcomed by the industry. To promote establishing the system, it is desired to start discussions with the industry as well as the relevant office of the Ministry of Commerce, which is the office responsible to guide the insurance industry.

(3) Conditioning and Preferential Treatment of Interest Rates

There are times when the owners/operators of existing buildings need access to loans, in such cases as the reform of interiors caused by a change of tenants, etc. Therefore it will be effective for improvement of existing buildings that the financial institutions adopt a rule by which the provision of a loan is made only if the building has a proper fire safety performance. Also, since raising of the safety level of a building leads to raising of the collateral value of the building, the preferential interest rate can be provided to buildings with better fire safety performance. Therefore it is desired that the discussion with the financial institutions should be started as soon as possible.

6.3.6 Promotion of Information Distribution and Human Resources Development

In Thailand, various kinds of statistics are prepared and basic information is substantially developed. However, the statistics are widely spread over a large number of administrative organizations. The statistics are not well processed, and they are not well utilized. In the field of building fire safety, the responsible departments have summarized basic statistics such as macroeconomy, a construction trend, the number of fires, and fire fighting facilities. However, the building control section has not collected and analyzed this data, and it has not compiled a yearbook. This is because the work not stipulated in the working code. In addition, the staff in the section do not have sufficient time to work on analyzing the data due to an insufficient number of human resources.

However, it is necessary to show that buildings in Thailand have a high risk of fire damage and to form a society sensible to fire safety of buildings. To achieve this, the building control department has to understand the trend of construction and fire and to clarify the issues to be tackled. As a result, the section should broadly disseminate information to the public in general. Recently, administration is largely changing in Thailand. With this opportunity of administrative change, it is expected that the system, in which information collection and dissemination are progressed, can be established.

(1) Establishment of Research Section

It is expected to establish in DPT a new section that exclusively deals with information collection and analysis for construction trend and fire as well as a quantitative grasp of problems becoming obvious. The former Department of Town and Country Planning (DTCP), which has been merged to the former Public Works Department (PWD), already has a research section for urbanization issues. By learning the former DTCP, a new research section for building technology is expected to be established in the new organization after the amalgamation or, alternatively, to strengthen the functions of the research section in the former DTCP.

On the other hand, reflecting the current attempt of restructuring to reduce authorities and work-force of governmental organizations, the alternatives for the foundation of the research section shall include the establishment within the research organizations, which are established outside the governmental organizations, discussed in the next section.

(2) Cooperation with Research Organization

There are a small number of researchers in the fire prevention field in universities. For example, the Chulalongkorn University has a section which conducts fire research. The expansion of this function as a research institute is planned in the university. The Kasetsart University also has a fire research section. It is significant to conduct research and development for the solution of specific subjects on fire prevention by cooperation with such researchers and research organizations, with respect of the development and improvement in fire prevention technology. It also leads to the production of talented human resources.

Furthermore, it is recommendable to establish a consultation committee consisting of these researchers. This organization is to judge the validity of the design and provide applicable solutions for architects/engineers engaged in the design work of a building which has unconventional features and not suitable for applying existing regulations and technical standards. By doing this, the risk for the architects and engineers to make critical mistakes will be largely avoided, while new architectural ideas and technologies can be adopted by flexible manner.

The consultation committee can be a self-sustainable organization if its works are financed by the applicants' expense. However, it is recommended that the government should support certain part of its operation cost to encourage average architects and engineers to use this opportunity more casually. If the system is activated properly, the number of challenging design will increase, while reducing the number of risky designs. Also, the experience accumulated in the committee will provide a reference documents that best match the needs of the professionals' community in Thailand.

(3) Capacity Building for Experts

The Building Control Section in the Ministry of Interior actively holds seminars to the staff in charge of building controls within local administrative bodies. As mentioned above, the staff consists of structural engineers and technicians without official qualification. Fire prevention technology requires the knowledge of technical fields, such as electricity and plumbing equipment which the staff do not specialize in. However, it is desirous for the staff to understand the basic concepts or skills of electricity and plumbing.

To this end, it is desirable for a technical manual to be prepared in this Study to be utilized in seminars and from which the staff can systematically obtain the knowledge.

Expanding such activity to a private specialist is also desired. For example, it is recommendable to disseminate information on the result of the research, technical development, and essential technologies.

Further, the qualification system for the professionals should take importance on the fire prevention technologies. Since both ASA and EIA have become independent quite recently, they are on the way of up-grading their respective qualification systems. In the light of raising the level of understandings among these professional people on fire prevention, we recommend that the qualification examination system should include basic aspects of fire prevention techniques. By doing this, those candidates for professional qualification holder will have to learn basics of fire prevention by themselves. For the architects, the examination should test practical knowledge by using sample drawings or asking to prepare drawing by the applicants. For the engineers, on the other hand, it is not simple because currently there is no title of qualification for the building engineer. For qualifying engineers practicing building engineering, the existing titles' system can be continued but knowledge for fire prevention technology should be additionally assured. To realize this, we recommend that the building control act should prescribe the requirement on professional engineers as a holder of the building inspectors certification on top of the conventional engineer's qualification, so that all the engineers must take the building inspector's qualification test which concentrate on building engineering matters including fire prevention technologies.

(4) Collaboration with Fire Departments

The Metropolitan Fire Brigade Division has identified only 20% of causes of fires. While fire departments take the responsibility for fire investigation, they have not found the most causes of fires, due to the police authority for inspecting the spot of fires and the insufficient technical capability of the fire departments. However it is necessary to collaborate between the building and fire fighting administrations to adequately draw up technical standards on which national consensus is given. In the practice for collaboration, the proposed research organizations shall provide technical support for the fire departments. It should be noted that precise analyses on causes of fires are prerequisite for the development of fire codes suitable for the country.

6.4 IMPLEMENTATION SCHEDULE

6.4.1 Implementation Schedule

The Implementation schedule for the programs mentioned in the section 6.3 is shown below. The Building Control Section in the Ministry of Interior, as the implementing body, will implement all activities upon coordination with the ministries and agencies concerned.

Figure 6.2: Implementation Schedule

Project/ Program	Organizations concerned	Short Term					Long Term	
		2002	2003	2004	2005	2006	2007	2015
JICA Study								
Amendment of BCA/New MR								
Issuance of Draft MR58	DPT(BCCB)							
Enhancement of Firesafety Requirements	DPT(BCCB)							
Control of Engineering Inspection/ S/V	DPT(BCCB)							
Control of Interior Design and Construction Works	DPT(BCCB)							
Approval System for Building Materials/ Components	DPT(BCCB, TISI)							
Issuance/ Revision of Technical Standards								
Improvement of Legal Structure	EIT							
Issueance of New EIT Standard	DPT(BCCB, EIT, ASA)							
Establishment of Coordination Body	DPT(BCCB, EIT, ASA, TISI)							
Revision of New EIT Standard	EIT(DPT, ASA)							
Establishment of ASA Standard	ASA(DPT, EIT)							
Establishment of Testing and Evaluation System								
Approval and Preparation of Testing Laboratory	DPT(BCCB, BMA, BO)							
Approval and Preparation of Evaluation Body	DPT(BCCB, BMA, BO)							
Establishment of Testing and Evaluation System								
Approval and Preparation of Testing Laboratory	DPT, TISI							
Approval and Preparation of Evaluation Body	DPT, TISI							
Establishment of Financial Support/ Incentive Systems								
Tax Reduction Incentive System	DPT, MOF							
Favorable Treatment in Fire Insurance	DPT, MOC (AOI)							
Conditionning and Favorable Financing System	DPT, MOF (AOF)							
Strengthening of Publicization and Human Development								
Establishment of the Reserch Sub-section	DPT(NSO, DOLA, DPS, PFB)							
Implementation of collaborative reserch with Specialized Institutions	DPT, MOUA (BMA, CU)							
Publication and holding of seminers	DPT, MOUA (EIT, CU)							

Note: Organizations in () are ones to support and/or cooperate with main responsible organizations.

Legend: AOF: Related associations of financial industry, AOI: Related associations of insurance industry, ASA: Association of Siamese Architects, BCCB: Building Control Committee Board, BMA: Bangkok Metropolitan Administration, BO: Building Owner/Operator, CU: Chulalongkorn University, DOLA: Department of Local Administration, DPS: Disaster Prevention Subdivision, DPT: Department of Public Works, Town and Country Planning, EIT: Engineering Institute of Thailand, MOC: Ministry of Commerce, MOF: Ministry of Finance, MOUA: Ministry of University Affair, NSO: National Statistical Office, PFB: Police Fire Brigade, and TISI: Thai Industrial Standard Institute.

6.4.2 Project Programs

Proposed projects and programs focus on extensive fields and the DPT has already started to realize some projects.

Amendment of the ministerial regulations was started by drafting up of modified MR 48 which will be submitted to the Building Committee Board for its consideration. On the other hand, the new ministerial regulation for periodic inspection and evaluation of existing buildings was submitted to the Council of State after the approval of the minister. After the consideration by the council, the new MR will be enforced upon the issuance by the Government Gazette. The DPT will establish a new sub-committee for technical inspection of interior finish works and under construction. It firstly aims to discuss about a proper measures for realization including legislation of new ministerial regulation.

Among the proposed projects and programs, the DPT will establish a new committee for an authorization system of building materials and assembled parts which includes representatives from the Chulalongkorn university and the Thai Industrial Standard Institute. In Thailand, technical knowledge and information in this field is not sufficient. Although the authorization system is important to support enforcement of ministerial regulations from technical aspects, it will be started from a very first step by preparation of necessary testing equipment and training of experts.

Establishment of testing organization should be done in the first phase for preparation of the authorization system. Things to be done in this phase are pointed out for development of the testing organization in the following.

As mentioned in the section 6.3.4, the DPT will prepare the requirements for designation of testing organization which covers tests for fire-resistance of structure and fire protection equipment, and materials of noncombustible interior finish. The test method should conform to the ISO standards and have fire testing equipment for the three fields: 1) fire-resistance construction, 2) fire protection equipment, and 3) fire-proof materials.

(1) Testing Equipment for Fire-resistance Tests - Elements of Building Construction (ISO834)

- Furnace for Fire-resistance Tests for Columns (capable for heating test with structural loading)
- Furnace for Fire-resistance Tests for Vertical Elements (exterior walls, partition walls, and fire protection equipment, i.e. fire doors)
- Furnace for Fire-resistance Tests for Horizontal Elements (beams, floors, and roofs)

(2) Testing Equipment for Fire Tests of Building Materials

- Testing Equipment for Reaction to Fire Tests for Building Products - Non-combustibility Test (ISO1182)
- Testing Equipment for Reaction to Fire Tests - Ignitability of Building Products Using A Radiant Heat Source (ISO5657)
- Testing Equipment for Fire Tests - Reduce Scale Model Box Test (DIS17431)
- Testing Equipment for Reaction to Fire Tests - Heat Release, Smoke Production and Mass Loss Rate from Building Products (ISO5660)
- Testing Equipment for Fire Tests - Full Scale Room Test for Surface Products (ISO9705)
- Testing Equipment for Fire Tests - Evaluation of Toxic Gas
- Testing Equipment for Fire Tests - Smoke Generation and Flame Propagation (preferably)

(3) Apparatus: monitoring devices and tools for manufacturing test specimens

Among the testing equipment mentioned above, the equipment for ignitability test (ISO5657), non-combustibility test (ISO1182), and small box test (DIS17431) were supplied to the DPT for a fire testing demonstration of the Study.

In current international momentum of test standards, the test method on the burning behavior of combustible building materials is moved to the cone calorimeter method (ISO5660) from ignitability test (ISO5657). Since the cone calorimeter method requires very stringent calibration, laboratory conditions, and elaborate operators, this method should be considered as a promising applicant for the future, when the testing skills and technologies are well-developed in Thailand.

A testing laboratory needs to adequately have air conditioning, smoke exhaust equipment, and water supply/treatment systems. To this end, the relation and effect of testing organizations for the aspect of building fire prevention development are shown in a Project Design Matrix (PDM) in the following.

Table 6.1: Project Design Matrix for Establishment of Testing Organization

Narrative Summary	Objectively Verifiable Indicator	Means of Verification	Important Assumptions
Overall Goal 1) Construction of buildings with high fire resistance 2) Development of buildings with fire protection equipment well-designed 3) Development of buildings with fire-proof materials graded properly	1) All of new buildings have required fire-resistance until 2015. 2) All of new buildings have required fire protection equipment until 2015. 3) All of new buildings have required fire-proof materials until 2015.	1) Statistics of building construction trend 2) Statistics of building construction trend 3) Statistics of building construction trend	
Project Purpose Development of social stocks of buildings in accordance with technical requirements and objectives of the country	All of new buildings and buildings targeted by current MR 33 conform to requirements of new technical regulations until 2009.	Statistics of building construction trend and building inspection on existing buildings	
Outputs 1) Preparation of technical requirements followed by architects/engineers 2) Development of building officials capable to evaluate conformity with technical requirements 3) Testing of performance for fire-resistance and fire-proofing 4) Evaluation of testing result reports 5) Development of an authorization system for fire-resistance structures, fire protection equipment, and fire-proof materials throughout all procedures from testing up to authorization	1) Amendment of technical requirements is completed until 2006. 2) Building officials in major cities completed training course for fire prevention until 2006. 3) Fire tests for structures, fire protection equipment, and building materials are commenced until 2006. 4) Test result reports are issued until 2006. 5) Authorization systems are applied for all of new buildings until 2006.	1) Latest version of fire codes 2) Statistics of training for building officials 3) Statistics of testing issued by testing organizations 4) Statistics of evaluation issued by evaluation organizations 5) Record of authorization issued by DPT	
Activities 1) Publication of technical guideline 2-1) Preparation of a manual for technical assessment of building fire safety 2-2) Holding seminars for building officials 3-1) Establishment of a testing system 3-2) Preparation of requirements for fire tests of materials 3-3) Implementation of training for testing 4-1) Establishment of an assessment system 4-2) Preparation of requirements for technical evaluation 4-3) Implementation of training for assessment 5-1) Designation of organizations for testing, evaluation, and authorization 5-2) Setting up roles of each related organization 5-3) Preparation of procedure documents for stages from testing to authorization	**Inputs** *Human resources* 1)Manager : 1persons 2)Deputy manager : 3persons 3)Engineer : 2persons 4)Technician : 2persons 5)Secretary : 2persons *Facilities* Land and buildings with adequate air conditioning, smoke exhaust equipment, and water supply/treatment systems. *Testing equipment* 1)Testing Equipment for Fire-resistance Tests - Elements of Building Construction (ISO834) 1-1)Furnace for Fire-resistance Tests for Columns (capable for heating test with structural loading) 1-2)Furnace for Fire-resistance Tests for Vertical Elements (exterior walls, partition walls, and fire protection equipment, i.e. fire doors) 1-3)Furnace for Fire-resistance Tests for Horizontal Elements (beams, floors, and roofs)	2)Testing Equipment for Fire Tests of Building Materials 2-1)Non-combustibility Test (ISO1182) 2-2)Ignitability of Building Products Using A Radiant Heat Source (ISO5657) 2-3)Reduce Scale Model Box Test (DIS17431) 2-4) Heat Release, Smoke Production and Mass Loss Rate from Building Products (ISO5660) 2-5)Full Scale Room Test for Surface Products (ISO9705) 2-6)Evaluation of Toxic Gas 2-7)Smoke Generation and Flame Propagation (preferably) 3)Apparatus: monitoring devices and tools for manufacturing test specimens	1)Assessment by trained building officials 2)Reference of publications 3)Coordination between relevant governmental organizations and authorities **Pre-conditions** Coordination between DPT and Chulalongkorn university

PART II REVIEW ON EXISTING FIRE CODES IN DIFFERENT COUNTRIES AND THAILAND

CHAPTER SEVEN:
FIRE CODES IN DIFFERENT COUNTRIES

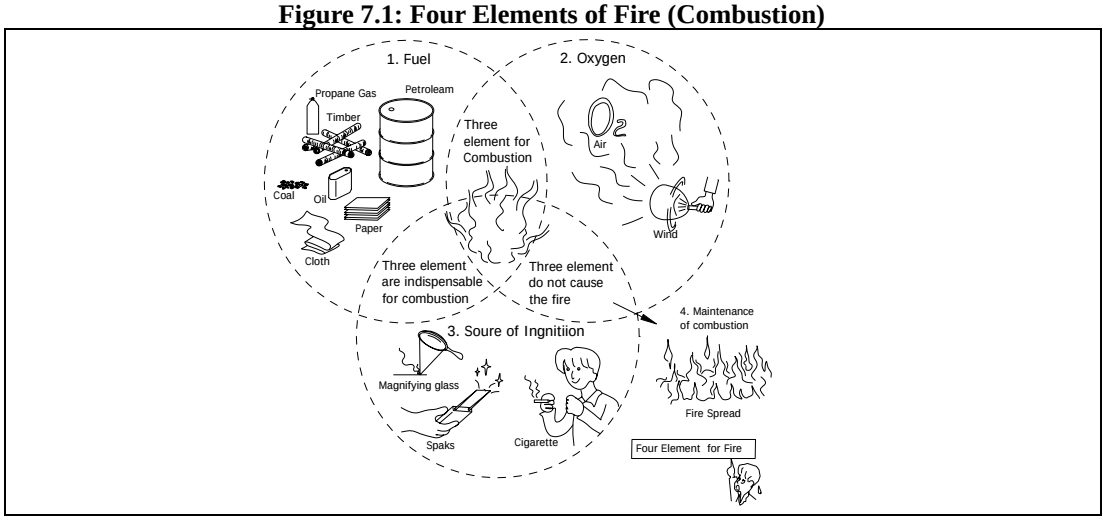
7.1 ELEMENTAL KNOWLEDGE OF FIRE PREVENTION SYSTEM

7.1.1 Basic Theories of Fire

(1) Nature of Fire

The nature of fire is a rapid and self-sustaining oxidation process with heat and light in varying intensities. In other words, fire can be defined as a phenomenon of combustion which is uncontrollable by mankind and which damages properties and lives. The "Fire-safety--Vocabulary (ISO 13943)" defines "fire" as "Expanding combustion independent from time and space". The combustion breaks out through the chemical reaction of three elements: Fuel (something to burn), Oxygen, and Source of Ignition (heat or thermal energy). The combustion grows into a fire, when the continuous supply of the three elements is further secured as the fourth element.

Figure 7.1: Four Elements of Fire (Combustion)



Source: JICA Study Team

(2) Development Stages of Fire

The fire, when broken out in a separated room, grows up by spreading over the surface of combustible materials in a room in its initial development stage. The flame spreads to furniture, walls, and ceiling. Heated gasses and smoke below the ceiling cause rapid fire spread along the walls by the thermal radiation. The intense combustion breaks windows and walls to make openings for the supply of the fresh air. As a result, the fire reaches to a full development stage. At the full development, the temperature and concentration of carbon monoxide (CO) and dioxide (CO_2) are

extremely high, while the concentration of oxygen becomes very low. The situation in the room becomes harsh for mankind.

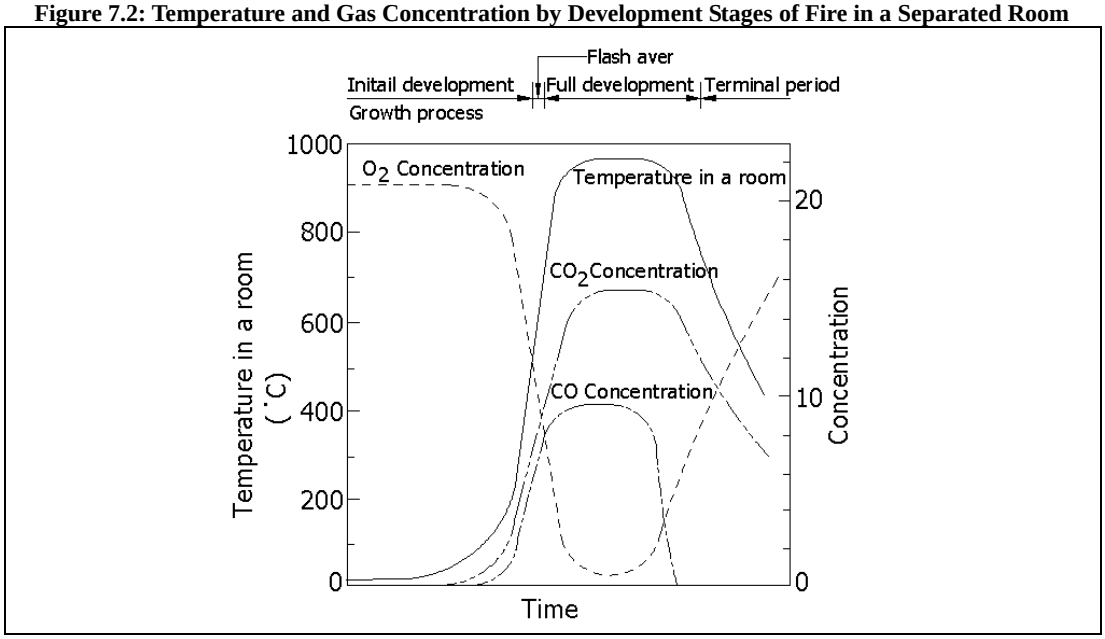
In the transition from the initial development to the full development, the temperature and the concentration of CO and CO_2 drastically increase, while the oxygen concentration falls down. This drastic change is defined as flash-over.

After consuming the combustible materials in the room, the fire moves into the fall-off stage. The temperature starts to decrease.

The development stages of fire consist of ten stages: (i) Before outbreak of fire, (ii) Outbreak of fire, (iii) Initial development, (iv) Flash-over, and (v) Full development in a room of fire origin. When the fire spreads from the room, the fire takes a further five stages: (vi) Fire spread to a room other than the room of the fire origin (fire spread on the same floor of the fire origin), (vii) Fire spread to a floor other than a floor of the fire origin, (viii) Fire spread in a whole building, (ix) Building collapse, and (x) Fire spread to other buildings (Exposure fire).

In practice, the fire can take stages between (iii) and (x) at the same time.

Figure 7.2: Temperature and Gas Concentration by Development Stages of Fire in a Separated Room



Source: JICA Study Team

7.1.2 Basic Theories of Fire Prevention System

(1) Purpose of the Fire Prevention System

The primal purpose of the fire prevention system is to secure the safety of human life and property and to minimize the damage caused by a fire.

There are two types of the fire prevention system: Fire prevention before the outbreak of fire and Fire protection after the outbreak. The former aims to prevent the outbreak of fire by soft components such as the control of heat resources and combustible materials. The latter implies the minimization of damage by physical fire protection systems, that is, various preparedness of building itself and equipment.

The required efficiencies of the fire protection systems are to limit the areas damaged by fire (Prevention of the fire spread), to control the generation and expanding of smoke (Smoke control), to secure the structural stability (Prevention of the building collapse), and to prevent the fire spread to adjacent buildings (Prevention of exposure fire). There is also a need to secure the safe evacuation routes (Evacuation safety) and to secure the safety of efficiency and safety for the fire fighting and rescue teams (Support for the fire fighting). Among the above-mentioned six requirements, the structure stability is indispensable to secure other conditions. Without this component, others could not work efficiently.

A fire, which is a phenomenon of combustion, is based on the principle of chemical reaction. The combustion creates flames and smoke which causes damage to properties and life. Therefore the required efficiency of a fire protection system is a universal matter, while the fires safety level differs depending on the characteristics of buildings and areas.

For example, fire extinguishing is to get rid of one of the four elements for fire. In other words, the removal of fuel, suffocation, cooling of fuel or interruption of chain oxidation reaction is necessary to extinguish the fire.

(2) Components of the Fire Prevention System

In this Study, elements of the fire prevention system are classified into seven categories that cover five phases for fire prevention: (i) Prevention of outbreak of fire, (ii) Prevention of initial fire development, (iii) Prevention of fire spread, (iv) Prevention of building collapse, and (v) Prevention of exposure fire. Those phases are supplemented by evacuation and fire fighting, which are taken actions throughout the fire development stages. The fire prevention system in each category has different purposes and elements as discussed with definition of typical terms in the following.

i) Prevention of outbreak of fire

The prevention of outbreak of fire takes the most important role to prevent the occurrence of a fire. It is mainly achieved by soft components, such as proper management and operation of heat resources, combustible materials, and buildings. Physical fire prevention systems avoid blind parts in a building, have fire preventive measures at habitable rooms having fire equipment and without window , and consist of having auxiliary fire equipment.

"Combustible Material": A material capable of undergoing combustion. *"Combustion"* means a chemical process that involves oxidation sufficient to produce light or heat.

"Habitable Room Having Fire Equipment": A room that is occupied by a building user and has fire or heat for its purpose of daily use, such as kitchen.

"Habitable room without Window": A room that does not have an area of window opening to the outside more than required area.

ii) Prevention of initial fire development

The prevention of initial fire development covers fire safety after an outbreak of fire until full development. It plays two roles: Securing prompt initial actions after the outbreak of fire and Preventing the fire development in the early stage.

The initial action is to carry out initial extinguishing, report to a fire department, and evacuation. It requires a fire detection system and an alarm and report system:

"Fire Detection System" aims to discover the outbreak of fire by detection which observes heat, smoke, or fire in a building and sends a signal to a receiving panel when the fire breaks out.

- **"Fire Detector"**: A device which senses ultraviolet and/or infrared rays radiated by fire.
- "**Smoke Detector"**: A device which senses visible or invisible particles of combustion.
- **"Heat Detector"**: A device which senses a heat increase by fire.
- **"Gas leakage detectors"**: A device which senses the concentration of visible or invisible leaked gasses.
- "**Electric Leakage Detectors"**: A device which reacts differences of incoming and outgoing electricity.

"Alarm and Report System" aims to properly inform the occupants of a fire by various types of information systems, such a fire alarm, public address system, automatic siren, emergency alarm tool, etc.

- **"Fire Alarm"**: A mechanism initiated by manual and/or electric signal that sounds by bells, buzzers, or speakers.
- **"Public Address System"** aims to inform a fire outbreak of occupants by a communication system in a building.

On the other hand, the prevention of initial fire development requires a portable fire extinguisher, an automatic sprinkler system, an indoor hydrant, and noncombustible interior finish.

"Automatic Sprinkler System" aims to suppress or delay the fire development by sprinkling fire extinguishing agents in initial stage of fire and extinguish fire in fire fighting stage.

- **"Fire Extinguishing Agent"**: A material for extinguishing fire that includes water, foam, inert gas (i.e. CO_2), or a chemical. The type of agent should be suitable for characteristics of objective rooms.
- **"Type of Sprinkler System"** mainly consists of three types: 1) Wet type with piping filled with pressurized water and useful for general buildings, 2) Dray type with piping filled with pressurized air and useful for freezing regions, and 3) Pre-action type filled with pressurized air, initiated by both of fire detectors and sprinkler heads, and useful for hospital, computer rooms, etc.

"Noncombustible Interior Finish" aims to delay the fire development by usage of noncombustible materials for interior finish at walls, ceiling, and floors.

- **"Interior Finish"**: The exposed interior surfaces of buildings including, but not limited to, fixed or movable walls and partitions, columns, and ceilings.
- **"Noncombustible Material"** in general: A material which in the form in which it is used, and under the conditions anticipated, will not aid combustion or add appreciable heat to an ambient fire. Materials, when tested in accordance with specified test standards, and conforming to the criteria contained in the fire codes shall be considered as noncombustible.
- **"Noncombustible Materials"** in Japan are those which are not combustible, damage, and don not generate hazardous gasses or smoke against fires for 20 minutes. In other words, those neither burn not undergo harmful cracking, melting or deformation etc. when subject to fire, and produce no harmful smoke or gas. These are inorganic materials such as concrete, mortar, bricks, tiles, asbestos panels, steel, aluminum, glass, and plaster.
- **"Quasi-noncombustible Materials"** in Japan are those which are not combustible, damaged, and do not generate hazardous gases or smoke against fires for 10 minutes. Those are burnt very little and produce little smoke or gas when subject to fire, and undergo no harmful cracking, melting or deformation etc. this classification includes cemented excelsior boards, gypsum boards, metal sidings, etc. which may contain little wood, paper, or plastic.
- **"Fire Retardant Materials"** in Japan are those which are not combustible, damaged, and do not generate hazardous gases or smoke against fires for 5

minutes. Those are wood and plastic that have either been given special chemical treatment or protected by metal coverings so that they do not burn easily. At the early stage of fire, these materials burn only slightly generating little smoke or gas and undergo practically no harmful cracking melting, or deformation that may spoil safe evacuation or endanger human life. Hard-to-burn plywood and FRP board are two typical materials in this category.

iii) Prevention of fire spread

The prevention of fire spread aims to limit the damaged area by subdividing a building by walls and floors with fire-resistance rating. Fire separation formed by the fire resistant walls and floors prevent the fire spread in the vertical and horizontal direction.

"Fire Barrier": A continuous membrane, either vertical or horizontal, such as a wall or floor assembly, that is designed and constructed with a specified fire-resistance rating to limit the spread of fire and which will also restrict the movement of smoke. Such barriers may have protected openings. Fire resistance walls and floors is a part of structure of fire barriers.

"Fire Separation/Compartment": A fire separation compartment is a space within a building that is enclosed by fire barriers on all sides including the top and bottom.

- **"Area Separation"** is arranged to prevent the horizontal spread of fire within a building, and to limit fire. It involves walls and floors of fireproof construction, fire door, and so on for each area unit of a certain size.
- **"Vertical Opening Protection"** aims to divide with fireproof floors, walls, or fire doors to prevent the rapid travel of fire and smoke in vertical spaces, such as staircases, hoist-ways, pipe spaces, and well-holes, etc. passing through several stories. The vertical opening protection secures safe evacuation. In addition, *"Vertical Opening"* means an opening through a floor or roof. Moreover, *"Atrium/Void"* means a floor opening or series of floor openings connecting two or more stories that is covered at the top of the series of openings and is used for purposes other than an enclosed stairway; elevator hoist-way; escalator opening; or utility shaft used for plumbing, electrical, air conditioning, or communication facilities.
- **"Mixed-use Fire Separation"** means to divide floors for different used in buildings of mixed occupancy or complex uses with wall or floors of fireproof construction, etc., or fire doors so that fire con be controlled within each compartment to secure efficient evacuation may be expected.
- **"Fire Separation at Incidental Use Area"** is to enclose a part, such as a habitable room with hazardous materials and having fire equipment, which is

important for fire safety.

To form the complete fire separation, any opening at the fire separation is required to have fire protection measures by:

"Fire Door" at an entry of a room, stairways, etc.,

"Noncombustible Filling" at a penetrated part by service shafts, etc,

"Fire Damper" at an inner part of air conditioning duct, etc,

"Fire Shutter" at a part which requires spatial continuity in the daily use, and

"Fire Window" at a window opening. It is a window assembly, including frame, wired glass, and hardware that meets the fire protective requirements for the location in which it is to be used.

"Spandrel": is to install a certain distance in horizontal and vertical directions between openings of different fire separations.

iv) Evacuation

An evacuation route has to secure safety for occupants from any point of a building to a safe area outside the building (Public way) before a fire causes hazardous conditions against evacuation. The evacuation route is consisted of three parts: Exit access, exit, and exit discharge as defined below.

"Exit Access": a part of an evacuation route which leads to an entrance to an exit.

"Exit": a part of and evacuation route that is separated from all other spaces of the building or structure by construction or equipment to provide a protected way of travel to the exit discharge.

"Exit Discharge": a part of an evacuation route between the termination of an exit and a public way. "Public Way" means any street, alley or other similar parcel of land essentially open to the outside air, deeded, dedicated, or otherwise permanently appropriated to the public for public use and having a clear width and height of specified sizes.

The evacuation route has to satisfy six elements: Continuity, Safety, Capacity, Redundancy, Ease of travel, and Ease for understanding.

"Continuity" without any obstruction from any point in a building to a public way.

"Safety" resistant against flame, heat and smoke.

"Capacity" sufficient for occupants by adequate width of evacuation routes. *"Occupant Load"* means the total number of persons that may occupy a building or portion thereof at any one time.

"Redundancy" sustainable for evacuation routes by securing two travelling routes or more and other fire preventive measures as listed below.

- **"Multiple Evacuation Route"** means provision of two evacuation route or more from any point to an exit.
- **"Maximum Exit Access Travel Distance"** is to secure that a required number of exits are located within a certain distance from any point to an exit.
- **"Maximum Common Path of Exit Access Travel"** is to secure a distance of the overlapping part of exit accesses where a point has multiple evacuation routes.
- **"Balcony Linking"** is to install a supplemental route by connecting balconies.
- **"Rooftop Safety Area"** means a rooftop area to connect escape stairways.
- **"Safe Separation/Area of Refuge"** means a area that is enclosed by fire resistance structures and has adequate floor are to temporarily store evacuees in an evacuation route.
- **"Horizontal Exit"**: A way of passage from one building to an area of refute in another building on approximately the same level or a way of passage through or around a fire barrier to an are of refuge on approximately the same level in the same building that affords safety from fire and smoke from the area of incidence and areas communicating therewith.
- **"Exit Sign and Exit Sign Illumination"**: Exit signs are devices that indicate proper direction of evacuation. Exit sigh illumination is a type of exit signs equipped with illumination which have required illumination intensity and is illuminated in the daily use and emergency.
- **"Emergency Lighting"** means a device that lights up evacuation routes and is turned-on in case where electric power supply is down.

"Ease of Travel" without any hindrance, such as stocked materials. It includes provision of handrails, selection of suitable floor surface materials without slippery conditions, uniform sizes of stairs, and flat floor surface, etc.

"Ease for Understanding" to lead occupants to a public way without perplexity or confusion.

An exit in a vertical direction mainly is formed by an escape stairway including an escape staircase, outdoor escape stairway, and smoke-proof staircase which has a vestibule or balcony in front of the staircase to prevent smoke intrusion.

"Through Stairway" means a stairway that has a direct access to a safety floor.

- **"Stairway"** means a set of stairs formed by rises and treads. On the other hand, *"Staircase"* means a stairway located inside a building and enclosed by structures

at all sides.

- **"Safety Floor"** means a floor that ahs an exit to the ground.

"Escape Staircase" means a type of though stairways that form a part of an exit. It is separated from the other parts of a building and enclosed by fire resistance walls.

"Smoke-proof Staircase" means a type of escape staircases that is accessed through vestibules or balconies from the other parts of a building. It is effective to secure an evacuation route highly resistant to smoke.

"Outside Escape Stairway": means a type of though stairways in which at least one side is open to the outer air.

Smoke resistance requires a noncombustible interior finish and a smoke control system:

- **"Gravity Smoke Exhaust System"** puts out smoke by buoyancy.
- **"Mechanical Smoke Exhaust System"** discharges smoke by mechanical force. This system basically requires smoke layers with sufficient depth to exhaust efficiently.
- **"Pressurized Smoke Control System"** is to prevent smoke intrusion and spreading into parts of buildings where air pressure is higher than adjacent parts of buildings by mechanical air supply.
- **"Smoke Barrier"**: A continuous membrane, either vertical or horizontal, such as a wall, floor, or ceiling assembly, that is designed and constructed to restrict the movement of smoke. A smoke barrier may or may not have a fire resistance rating. Such barriers may have protected openings.
- **"Smoke Enclosure/Compartment/Separation"**: A space within a building enclosed by smoke barriers or fire barriers on all side, including the top and bottom.
- **"Smoke Curtain"** in Japan aims to retard smoke spreading in the initial fire stage by hanging walls made with noncombustible materials and having more than 80 cm length in vertical from ceilings.

v) Support for Fire fighting

Support for fire fighting aims to secure efficiency and safety for fire fighting including rescue. It requires accessibility for firefighters to a building and within the building.

"Firefighters' Access" is to provide an access road for firefighters to a building.

"Window for Firefighters" means a window opening where firefighters may enter into a building.

"Elevator for Firefighters" is a elevator that is used by firefighters in case of fires.

"Life Lobby for Firefighters" is a space where firefighters may stay for their fire fighting activities. It is used for a base of fire fighting and rescue and equipped with emergency electrical outlets and fire hydrants.

The support also needs equipment for fire fighting.

"Indoor Fire Hydrant" has mainly two types: one for firefighters and the other for trained building users. In general, it is used for extinguishing fire.

- **"Fire Department Connection"** is a type of indoor hydrants that has a connection located at outer surface of external walls. Pump trucks supply pressurized water to higher floors through riser pipes installed in building structures.
- **"Sprinkler System with Hose Connection"** is a type of indoor hydrants that also has a connection for pump trucks. It is connected to spray heads in underground floors.

"Radio Communication System Support Equipment" is a system installed in a building that supports radio communication between firefighters.

"Emergency Power Supply Unit" aims to supply electric power for fire protection system including detectors, alarms, lighting/illumination, and fire pumps, etc. Generator or battery suitable for the system supply the power for a certain period.

On the other hand, a building having a mixed classification and/or large floor areas is required to have an adequate management system.

"Fire Fighting Control Room" is a room that is designed to supervise the fire protection system in the daily use and become the command center for fire fighting in the case of fire

vi) Prevention of building collapse

The prevention of building collapse is to secure fire resistance of a structure, including a wall, column, floor, and beam, which holds the structural load of a building and forms a important part of the fire evacuation system, such as a floor of a rooftop safety area and a wall of an escape stairway.

"Fire-resistance Rating": The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as established in accordance with the test procedures specified in fire codes.

"Standard Time-Temperature Curve" means a standard heating temperature for testing of fire-resistance rating. It is specified in ISO834 with a relation to a duration of heating: T-To=345log10(8t+1). (whereby, T: temperature at current time, To: temperature before heating, t: time of heating)

vii) Prevention of exposure fire

Prevention of exposure fire is to prevent fire spread to adjacent buildings.

"Safe Distance between Buildings" is to separate buildings as far as possible, so that the fire and sparks are not able to reach an adjacent building.

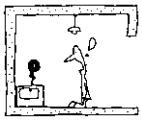
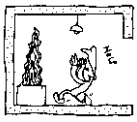
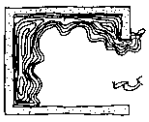
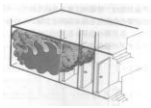
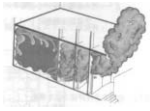
"Fire Resistant Construction of External Walls and Roofs" means construction of external walls, roofs, eaves, and openings by fire resistant materials. Those are main parts to catch a fire.

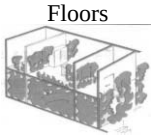
(3) Type of Fire Protection System (Active and Passive Systems)

The fire protection systems can be categorized in two parts from the viewpoint of mechanism: Active system and Passive system. The former implies facilities that need power supply of electricity or water, while the latter is formed by a building itself, such as fire separation and evacuation routes. For example, a fire door with automatic closing is a kind of the passive system, however it can be categorized into the active system when it is interlocked with fire detectors.

The active system can work correctly and efficiently as long as appropriate maintenance is provided. Therefore, the passive system should ensure fires safety to avoid a catastrophic situation, while the active system contributes to improve fire safety secured by the passive system. Demarcation of the passive and active systems in the seven categories are shown in the following table.

Figure 7.3: Fire Prevention System in the Seven Categories

<table>
<tr><th>Fire Develop. Stages</th><th>Category</th><th>Fire Prevention</th><th>Evacuation</th><th>Support for Fire Fighting</th></tr>
<tr><td>Before Outbreak of Fire</td><td>Prevention of Outbreak of Fire</td><td>(Operation)
• Management of Heat Resource
• Limitation of Combustibles
• Proper Maintenance and Operation
• No Blind Space</td><td></td><td></td></tr>
<tr><td>Outbreak of Fire
  </td><td rowspan="4">Prevention of Initial Fire Develop.</td><td rowspan="4">(Passive System)
• Noncombustible Interior Finish
(Active System)
• Fire Detection System (Fire, Heat, Smoke)
• Electric Leakage Alarm System
• Gas Leakage Alarm and Indication System
• Emergency Alarm System (Fire Alarm, Public Address System, Automatic Siren)
• Portable Fire Extinguisher
• Automatic Sprinkler System (Dry / Wet Types, Water / Spray / Form / Chemical / Inert Gas / CO_2 Agents)
• Indoor Fire Hydrant</td><td rowspan="11">(Passive System)
• Continuous, Clear and Sufficient Evacuation Route (Multiple Evacuation Routes, Maximum Exit Access Travel Distance, Maximum Common Path of Exit Access Travel, Capacity)
• Escape Stairway (Escape Staircase, Outdoor Escape Stairway, Smoke-proof Staircase)
• Horizontal Exit (Area of Refugee)
• Noncombustible Interior Finish
• Fire Separation
• Rooftop Safety Area
• Balcony Linking
• Smoke Control (Gravity Smoke Exhaust System, Smoke Curtain, Smoke Separation)
(Active System)
• Smoke Control (Mechanical Smoke Exhaust System, Pressurized Smoke Control System)
• Exit Sign Illumination
• Exit Sign
• Emergency Lighting
• Public Address System</td><td rowspan="11">(Passive System)
• Fire Fighters' Access
• Window for Fire Fighters
• Life Lobby for Fire Fighters
(Active System)
• Indoor Fire Hydrant
• Outdoor Fire Hydrant
• Fire Department Hydrant
• Sprinkler System with Hose Connection
• Emergency Electric Outlet
• Elevator for Fire Fighters
• Fire Fighting Control Room
• Heliport</td></tr>
<tr><td>Initial Develop.
  </td></tr>
<tr><td>Flash-over
  </td></tr>
<tr><td>Full Develop.
  </td></tr>
<tr><td>Fire Spread to Rooms
  </td><td rowspan="3">Prevention of Fire Spread</td><td rowspan="3">(Passive System)
• Area separation
• Vertical opening protection
• Mixed-use fire separation
• Fire separation at incidental use area
• Spandrel

(Active System)
• Smoke control equipment
• Fire door
• Fire shutter</td></tr>
<tr><td>Fire Spread to Floors
  </td></tr>
<tr><td>Fire Spread to the Whole Building</td></tr>
<tr><td>Building Collapse</td><td>Prevention of Building Collapse</td><td>(Passive System)
• Fire resistant construction (fire-resistance rating)</td></tr>
<tr><td>Exposure Fire</td><td>Prevention of Exposure Fire</td><td>(Passive System)
• Fire Protection of External Wall and Roof
• Fire Protection of Opening
• Drencher</td></tr>
</table>

Source: JICA Study Team

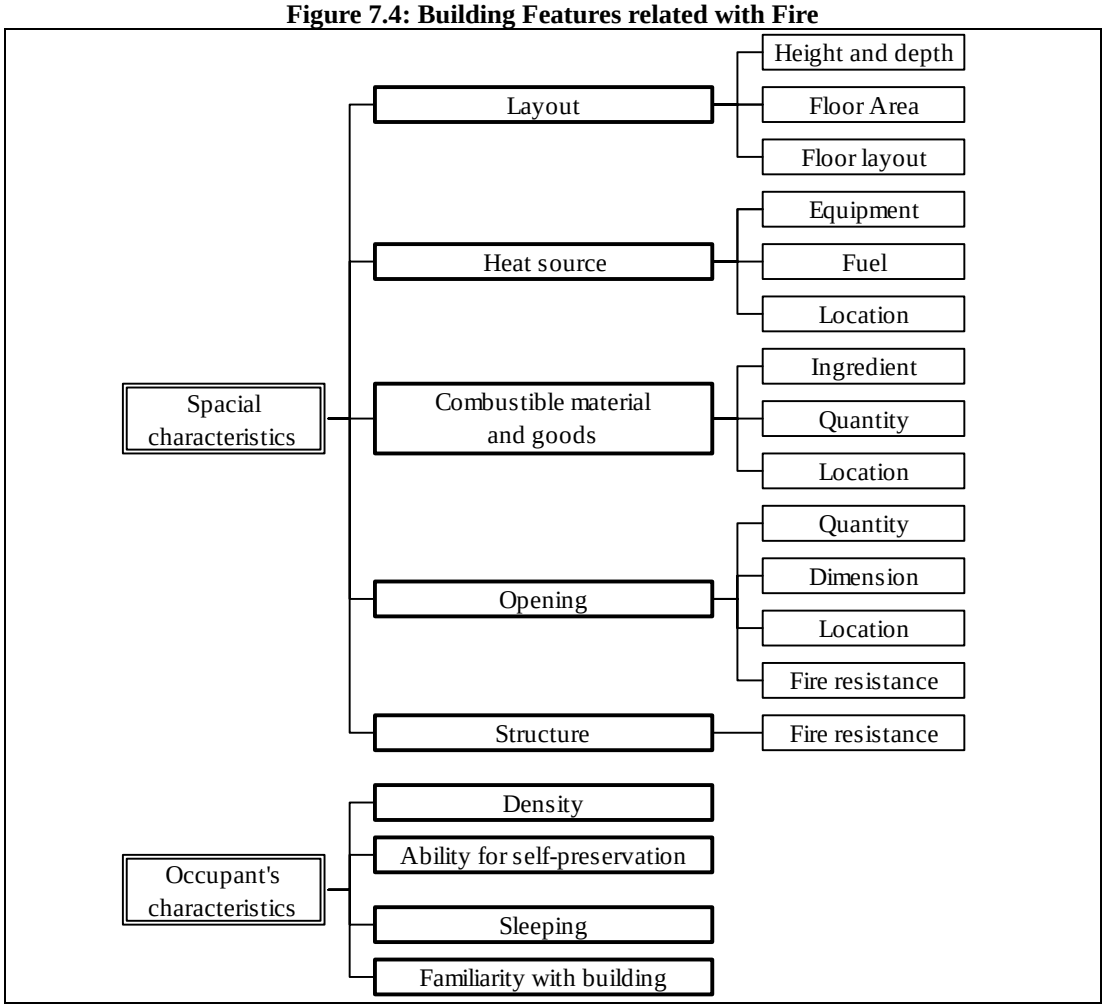
(4) Building Features related with Fire

The features of a building from the viewpoint of fire are categorized into (1) a spatial characteristic and (2) a characteristic of occupants in the building. The former generally means the shape of a building, heat resource, and combustible materials. The shape of a building includes height, floor area, and floor layout of the building, while the heat resource covers quantities, location, and types of fuel and fire equipment.

The latter implies the occupant density (person/m^2) and the occupant's acquaintance with a building. It also covers whether the occupants sleep in the building or not, and whether they can evacuate by themselves or not. The occupants' acquaintance with a building affects the efficiency of initial actions and evacuation. The ability for self-preservation depends on the occupants' mental and physical condition.

Although a fire is a phenomenon of combustion, which follows the law of science, it is not easy to clarify the fire safety of a building. Because the building features related with fire includes numerous characteristics of the building. In other words, every element about a building has fire safety consequences. For example, for the home kitchen range: if the controls are placed in front, there is a greater risk of fire started by children playing; if the controls are placed at the back, there is a greater risk of clothing ignition during ordinary use.

Figure 7.4: Building Features related with Fire



Source: JICA Study Team

7.2 FIRE CODES IN DIFFERENT COUNTRIES

7.2.1 Basic Composition of Fire Codes in Different Countries

(1) Fire Codes to be examined

This section discusses the comparison of the contents and requirements of fire codes in different countries. The compared countries are six in all; Firstly, the United States of America, England, and Australia that are often referred to by architects and building engineers in Thailand, secondly, Malaysia and Indonesia that are similar to Thailand regarding socioeconomic conditions, and finally Japan.

Fire codes in the six countries have a multi-layered structure formed by “Code/Act”, “Regulation/ Enforcement Order “, “Rule”, “By-law/Ordinance”, and “Standard”. In this Study, “Code/Act” and “Regulation/Enforcement Order”, that provide basic requirements on the fire prevention systems are examined.

The “By-law/Ordinance” strongly reflects local characteristics, while the “Standard” relates to industrial products in individual countries. Therefore those regulations are irrelevant to this Study. The fire codes dealt with here are as follows.

i) Japan: Building Standard Law (BSL), Enforcement Order under the BSL, Fire Service Law (FSL), and Enforcement Order under the FSL.

ii) United States: International Building Code (IBC) and International Fire Code (IFC)

iii) England: Approved Documents B under the Building Act (BA)

iv) Australia: Building Code of Australia

v) Malaysia: Uniform Building By-laws 1984 (UBB)

vi) Indonesia: National Building Code (NBC)

The standard of NFPA（National Fire Prevention Association）is referred to most often among fire codes of the different countries in Thailand. In a legal structure in the USA, it is placed as one of the “Reference Codes” under the International Building Code (IBC) that is a model code issued in 2000 to integrate three American major codes: the National Building Code, the Standard Building Code, and the Uniform Building Code. Therefore an examination of requirements in the IBC simultaneously implies the study on the NFPA standards.

On the other hand, the Uniform Building By-laws 1994 is promulgated to establish a standard by-law for local administrations. It forms basic requirements of building codes in Malaysia.

(2) Composition and Type of Fire Codes

Enforcement Orders in BSL (Japan), IBC (USA), Approved Documents (England), and BCA (Australia) have specific chapters and sections for the fire prevention system. The structure of chapters and sections is different from one to another.

For instance, the Enforcement Order under BSL specifies regulations on the fire prevention system in the sections such as; “Fireproof Construction, Quasi-fireproof Construction, Fire Preventive Construction, Fire Separations”, “Evacuation Facilities”, “Interior Finish of Special Buildings”, “Large-scale Buildings with Principal Building Parts made of Wooden Construction” and “Building Equipment”. IBC specifies in four chapters; “Fire-resistance-rated Construction”, “Interior Finishes”, “Fire Protection Systems”, and “Means of Egress”.

The Approved Documents specify in five chapters; “Means of Warning and Escape”, “Internal Fire Spread (linings)”, “Internal Fire Spread (structure)”, “External Fire Spread”, “Access and Facilities for the Fire Service”. The Building Code of Australia covers the fire prevention system in three chapters; “Fire Resistance”, “Access and Egress”, and “Services and Equipment”.

In the four developed countries, the performance based codes are totally or partially adapted for the fire codes. The performance based code is to specify required performance, such as fire-resistant ratings, while the specification based code specifies detailed and specific requirements, such as the minimum thickness of fireproof covering which complies with the required fire-resistant rating.

In the BA (England) and the Building Code of Australia, all fire codes employ the performance based codes together with specification based codes stipulating the minimum requirements needed to comply with the necessary performance. Those specification based codes are named as “Deemed to Satisfy” in the Building Code of Australia and stipulated in the Approved Documents in England. In practice, the fire code that includes the performance based code is enforced upon the support of the specification based code.

In the BSL (Japan) and the IBC (USA), performance based codes are partially introduced. Both fire codes specify required performance, for fire-resistant ratings of structures, fire protection equipment, and noncombustible materials. In 2000, the BSL was supplemented with verification methods for the evacuation safety and the fire resistance of structures. If evacuation safety of a building is judged safe by the verification method, some requirements can be excepted.

Enforcement of a performance based code requires a verification method and testing standard that evaluates the compliance of the proposed fire prevention system. The

enforcement should be further supported by the specification based code to maintain the convenient application of the fire codes.

(3) Fire Codes on Special Buildings and Technologies

Every building has unique features in the viewpoint of the fire safety. On the other hand, the construction technology is developing day by day. Therefore, it is not suitable to regulate the fire safety by an uniform standard. In the four developed countries, the fire codes adapt technical judgements and verification by experts and reliable institutes.

In the BSL (Japan), a document of the disaster prevention planning is required for any building having a large floor area and mixed building uses. After the document is technically evaluated by a reliable institute, an approval by the Minister will be issued for the construction of the building. Due to decentralization in Japan, the necessity for such a document currently depends on the by-laws issued by local governments. However, the evaluation by the reliable institute is still requested by the local administration as same as the situation before the amendment of the BSL, to secure the fire safety of special buildings. In the United States, a building official receiving the application document has the authority to judge the necessity of technical evaluation by experts. This technical evaluation process by the experts in USA is named “Peer Review”.

(4) Alleviation and Trade-off

Fire codes in foreign countries specify the alleviation and trade-off of the fire prevention system to find out the proper fire safety level. The trade-off aims to eliminate an excessive system, of which the purpose overlaps with an another system. The alleviation is based on the consideration that a part of the fire prevention system can be replaced by an another system. The alleviation and trade-off are necessary to avoid excessive requirements and to leave options for the planning.

In Japan, a noncombustible interior finish is excluded by the trade-off with provision of an automatic sprinkler system and smoke exhaust system. This is because interruption of a fire from developing by noncombustible materials is replaced by the automatic sprinkler system, while the smoke exhaust system discharges out smoke and toxic gas generated from combustible materials. Installment of an automatic sprinkler system permits, as an alleviation, enlarges a specified floor area of the area separation. Noncombustible interior finishes allow the maximum exit access travel distance to be longer.

In the United States, installment of an automatic sprinkler system brings various alleviation for the maximum exit access travel distance, the width of evacuation routes, the grade of interior finish materials, and the fire-resistance rating of

structures and fire protection equipment. The alleviation by the sprinkler system is due to the deep relationship between the fire prevention and the insurance industry, which has taken the initiative on the fire safety systems in the country. The installment of a sprinkler system also provides an advantage to reduce the premium of the fire insurance.

(5) Classification of Building

Classification of Building in the fire codes defines the types of building use to reflect the spatial and occupant characteristics of buildings. It contributes to generalize the quantity of combustible materials and floor layout of a building. The occupant characteristics, such as the density, sleeping conditions, possibility of self-evacuation, and acquaintance with a building, can be also reflected by the classification of building.

The required fire prevention system of a building is specified in the fire codes by the classification of building, total floor area, and height of the building.

In the different countries except Indonesia, the classification of building is categorized into six to ten groups. IBC (USA), BA (England), and the Building Code of Australia further subdivide the classification into twenty-six, eleven, and fourteen subgroups, respectively.

The IBC defines the most detailed groups. The classification is firstly divided into ten groups of Assembly, Business, Education, Factory Industrial, Hazardous, Institutional, Merchandise, Residential, Storage, and Miscellaneous. Those groups are secondly subdivided into twenty-six subgroups by the number of occupants, hazardous materials, and condition of building use. On the other hand, the BSL (Japan) categorizes the classification of building into six groups of Halls, Hospital/Hotel/Apartment, Education, Department store, Storage, and Garage.

In general, the classification of building includes individual groups of assembly, merchandise, storage, and factory industrial. Categorization of other groups, such as residential, education, institutional, and hazardous are different by fire code to another. It is presupposition for a complex building use that a building is subdivided into a single use by fire separation, then the requirements for the subdivided use are determined as the single building use.

7.2.2 Fire Prevention System in Fire Codes in Different Countries

Here the principal requirements of the fire codes in different countries are examined by fire prevention stages. The discussion focuses on the physical fire protection systems, therefore soft components, such as management and periodic inspection in the prevention of outbreak of fire, are excluded. The principal requirements are itemized according to the Building Standard Law and the Fire Service Law in Japan.

(1) Prevention of Initial Fire Development

The developed countries of Japan, the United States, England, and Australia specify the fire detection system, the alarm and report system, and the automatic sprinkler system in their fire codes.

The fire codes reflect different consideration in details. The International Building Code (USA) gives the priority to smoke detectors, while the Fire Service Law (JPN) tends to reflect the characteristics of a habitable room for the selection of types of detectors.

Although the International Building Code (USA) and the Approved Documents (England) require noncombustible interior finishes at walls, ceilings, and floors, the Building Standard Law (JPN) and the Building Code of Australia specify this necessity at walls and ceilings only. Upon the common understanding that main routes of fire development are walls and ceilings from viewpoint of the combustion science, all of the four fire codes at least adapt the necessity for walls and ceilings.

(3) Prevention of Fire Spread

The IBC (USA) has no requirement of the area separation, however it specifies the fire resistant walls for partitions of every housing unit and tenant space to complement the area separation.

Other fire codes in Japan, England, and Australia commonly require the four types of the fire separation. In detail, requirements of the vertical opening protection in Japan are different from the other two countries. The BSL (JPN) requires the protection at the vertical openings penetrating through three floors or more, while the fire codes of the other two countries are based on the cubic volume of the vertical openings.

Supposing the high risk by fire spread to floors, the fire codes of the four countries commonly specify the vertical opening protection. These codes also require fire separation to subdivide a complex building into a single building use in order to simplify evacuation and fire fighting activities.

(4) Evacuation

The four developed countries specify evacuation facilities based on the number of occupants. The BSL (JPN) specifies the requirements based on the floor area, however it can be converted to the number of occupants by the occupants' density (person/m^2).

A major difference between the four countries is a definition of the evacuation route. This consists of three parts: Exit access, Exit, and Exit discharge. In the countries other than Japan, the exit is defined as the route in the horizontal and vertical

direction being separated by fire resistant constructions. The BSL (JPN) basically considers the exit as the escape stairways only.

Other differences are the necessity of the smoke curtains and the rooftop safety areas. The former is excluded from three countries, due to the distrust of the smoke storing abilities by the smoke curtains. The exclusion of the latter is due to the uncertain possibility to change escape stairways via the rooftop safety area.

(5) Support for Fire Fighting

The Approved Documents (England) and the Building Code of Australia do not specify outdoor fire hydrants. Those countries consider indoor fire hydrants as a more effective measure than the outdoor hydrants. In practice, the BSL (Japan) and the IBC (USA) exclude outdoor fire hydrants on large and high-rise buildings. Both fire codes recommend the installation of indoor fire hydrants.

The Approved Documents and the BSL (Japan) have no requirements for fire fighting command rooms, however a command room is practically recommended in the course of building permissions for large, high-rise, and mixed-use buildings.

(6) Prevention of Building Collapse

The fire codes specify the fire-resistant rating of principle structures to secure the structural stability of a building. The BSL (Japan) takes into account reuse of the building after the fire, the IBC (USA) requires the structural stability only during the fire. These different concepts are reflected in the fire testing standards. However the items of requirements are similar in the four countries.

(7) Prevention of Exposure Fire

The fire codes of the four developed countries commonly require fire resistant external walls and roofs.

(8) Summary

The number of the requirements in the Uniform Building By-laws (Malaysia) and the National Building Code (Indonesia) remains around half of that of the four developed countries.

The UBB has already induced fire protection systems against the initial fire development and the fire spread, but when it comes to evacuation, fire fighting, and prevention of building collapse, there are still a lot of things to be done. This is especially with regards to evacuation, the supporting equipment, emergency lighting and exit sign illumination, and smoke control systems, which have not been introduced yet. The NBC has a similar fire protection system requirement to the UBB.

The NBC ranks after the UBB in terms of detection and reporting systems and escape stairways.

By and large, the fire protection systems are the similar between the four developed countries: Japan, USA, England, and Australia. It might be natural that the methods for the fire protection for human lives and properties are similar to each other in all countries, because the phenomenon of a fire is universal in all countries. These countries have been amended their fire codes with reference to other countries' systems and experiences.

In details, the required fire protection systems by the use and size of a building are different from country to country, reflecting the country's particular socioeconomic conditions and experiences.

Table 7.1: Requirement of the Fire Protection System in Fire Codes of Six Countries

Fire protection Stage	Fire protection by Progress of Fire		JPN	UK	USA	AUS	MAL	IND
Prevention of Initial Fire Development	Detection, Alarm, and Report	Fire Alarm System	●	●	●	●	●	
		Detection System	●	●	●	●	●	
	Initial Fire Extinguishing	Portable Fire Extinguisher	●		●	●	●	
		Automatic Sprinkler System	●	●	●	●	●	●
	Noncombustible Materials for Interior Finish	at walls	●	●	●	●	●	●
		at ceiling	●	●	●	●	●	●
		at floor		●	●			●
Prevention of Fire Spread	Fire Separation	by area	●	●		●	●	●
		at vertical openings	●	●	●	●	●	●
		by different occupancy	●	●	●	●	●	●
		at incidental parts	●	●	●	●		
	Fire Separation at Openings	Non-combustible Fillings at Penetrated Parts	●	●	●	●	●	●
		Fire Doors	●	●	●	●	●	●
		Windows with Fire Resistance	●	●	●	●	●	●
		Air Ducts and Pipes	●	●	●	●	●	●
		Fire Damper with Automatic Closing	●	●	●	●	●	●
Evacuation	Evacuation Planning	Multiple Evacuation Directions	●	●	●	●	●	●
		Maximum Exit Access Travel Distance	●	●	●	●	●	●
		Maximum Common Path of Exit Access Travel	●	●	●	●		
	Stairways	Through Stairways	●					
		Fire Escape Stairways	●	●	●	●	●	
		Smoke-proof Stairways	●	●	●	●	●	
		Outside Fire Escape Stairways	●	●	●	●	●	
	Exit Discharge		●	●	●	●		
	Form of Doors		●	●	●	●		
	Supporting System for Evacuation	Rooftop Safety Area	●		●			
		Balcony Linking	●	●	●	●		
	Lighting and Exit Signs	Exit Sign	●	●	●	●		
		Exit Sign Illumination	●	●	●	●		
		Emergency Lighting	●	●	●	●		
	Smoke Control	Smoke Curtain	●					
		Smoke Enclosure	●	●	●	●		
		Smoke Control Equipment	●	●	●	●		●
	Emergency Electricity Supply		●	●	●	●	●	●
Fire Fighting	Elevator	Elevator for Fire Fighters	●	●	●	●	●	
	Fire Plug	Indoor Fire Hydrant	●	●	●	●		
		Outdoor Fire Hydrant	●		●			
	Radio Communication System Support		●		●	●		
	Fire Fighting Control Room				●	●	●	
Prevention of Building Collapse	Fire Resistant Construction	Fire Resistance of Column, Beam, Stair, and Wall	●	●	●	●		
		Fire Rating of Principle Structure	●	●	●	●		
Prevention of Exposure Fire	Fire Resistance on External Wall and Roof		●	●	●	●	●	●

Source: JICA Study Team

Legend: ●- Specified in a fire code.

JPN: Japan, ENG: England, USA: United States of America, AUS: Australia, MAL: Malaysia, and IND: Indonesia

7.2.3 Technical Limitations of Verification of Fires Safety and Improvement of Fire Codes

(1) Rational Fire Safety Level

The highest fire safety level is to maintain damage to life and properties to none. However it is practically impossible to realize this extreme level even with the best building design and the sufficient usage of cost for construction and maintenance, though it might be possible to minimize damage.

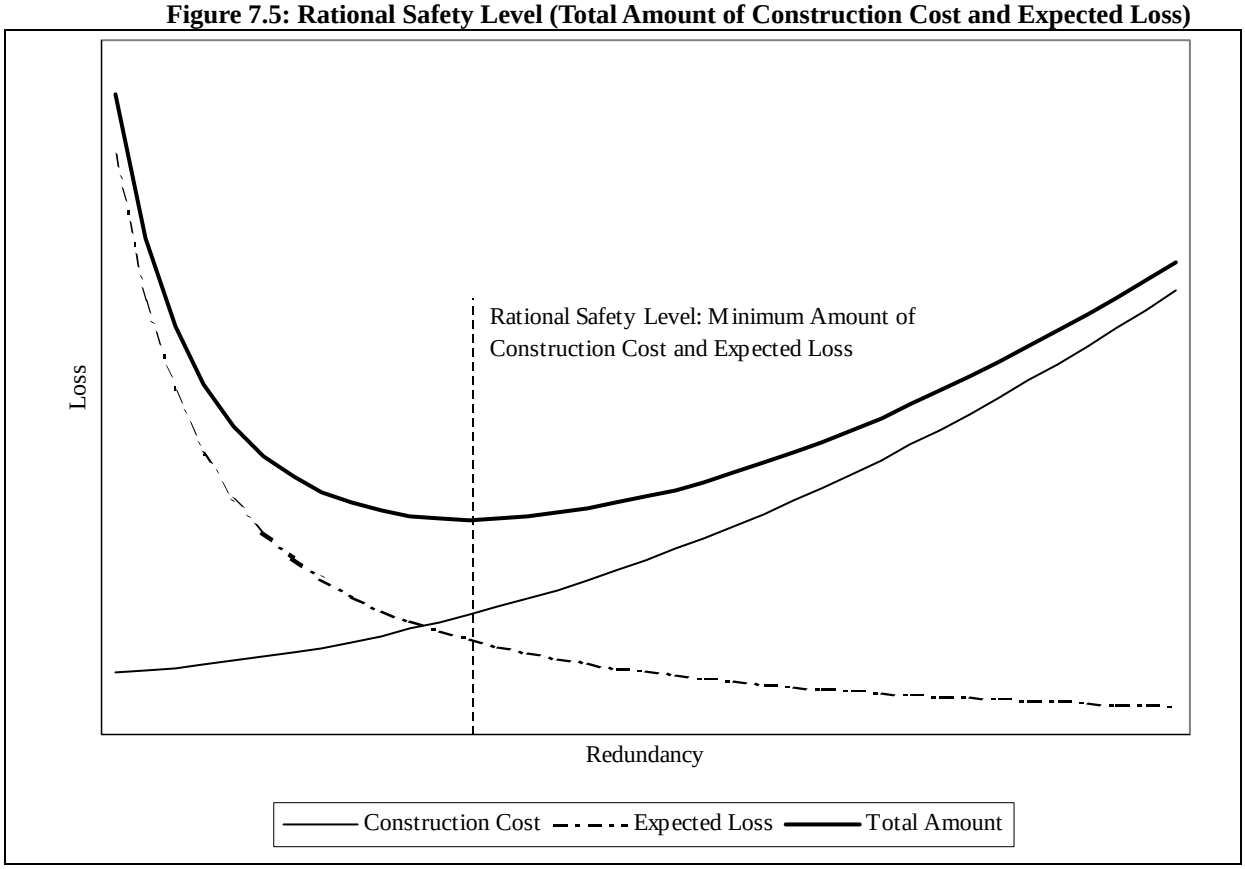
Therefore, a rational fire safety level would be that loss of lives is secured to be none and that the total amount of construction and maintenance cost and expected loss would be minimal.

Though it is possible to conceptually decide a rational fire safety level, no verification method has been developed to evaluate the total amount of cost and expected loss of a building. The reasons are; 1) The testing of a full-scale building is difficult, 2) The elements that influence the fire are numerous and different from case to case. In other words, no typical case can be found for the verification. Presently verification methods cover specific fields, such as evacuation and fire resistance of the structure. Those methods are not able to comprehensively evaluate the fire safety level of a building.

In 2000, an amendment of the Building Standard Law in Japan adapted verification methods for the evacuation safety and the fire resistance of a structure. The former method evaluates the required time for evacuation and the time for smoke to reach a hazardous level, by calculation with numerical formulas. The latter method is to simulate the temperature rise and dynamic influence of structures by expected temperature and duration of heat. These methods are applicable to specified fields on fire safety by logical calculation, but not suitable to evaluate the overall fire safety level of a building.

In any country, the fire code has been developed based on the socioeconomic conditions and experience of fire cases. As it is difficult to evaluate the fire safety level scientifically, the fire code has been repeatedly revised after particular fire cases. With repetition of numerous amendments, the fire code has come to be effective to some extent in Japan and in the United States of America, as a reduction in casualties and damaged floor area has resulted.. The fire codes in both countries have the possibility to be amended again, reflecting socioeconomic change and any particular fire cases in the future.

Figure 7.5: Rational Safety Level (Total Amount of Construction Cost and Expected Loss)



(2) Historical Changes of Fire Codes and Their Effects

i) Historical Changes in Europe and America

The fire code was originally developed to prevent conflagration. In the last hundred years, the fire codes against building fire have been modified with the change in the complexity and enlargement of buildings.

It is said that the fundamental of the modern fire code was established following the event of the great fire in London in 1666. This calamity destroyed three thirds of the whole London, inflaming some 13,000 buildings. The law that was newly set up to reconstruct the City of London, compelled new construction to provide for the fire resistance of external walls and roofs and to abolish wooden frame construction and narrow roads. In the United States of America, the fire code was drastically amended after the conflagrations in Chicago and Boston in the late 19th. Century, aiming at enlargement of roads and increase of the fireproofing of buildings.

In those days, the fire codes induced the viewpoint of city planning, due to frequent occurrence of conflagrations. The fire code introduced the designation of fire areas

and the fire resistance of external walls and roofs. Those requirements have been reflected in the current fire codes.

Later, conflagrations came to be rare in the developed countries owing to the promotion of fireproof buildings and the improvement of public fire services. Conflagrations in the 19th. Century originated from large earthquakes: San Francisco in 1906 and Kobe in 1995.

The fire code for individual buildings was developed in New York City when skyscrapers started to appear. The fire code was set up in New York City in 1888, following the fire of a five-story building in which twelve lives were lost. Then, criteria for fire preventive measures at windows and for evacuation facilities were introduced after fires in high-rise buildings; a sixteen-story building with sixteen casualties in 1898 and a ten-story building with 145 casualties in 1911. A large fire in a theater (in 1903), from which the death toll reached 602, especially influenced the fire code in the America and in other countries. A new fire code specified the necessity of a sprinkler system, indoor fire hydrant, and fireproof curtains.

In Europe also, the fire code was systematically improved during the later part of the 19th. Century, after evaluation of the large fires in other countries. Some of these fires recorded casualties of more than hundred, for instance:

- 640 casualties by a fire in a theater in Austria in 1881,
- 183 casualties by a fire in a hall in England in 1883, and
- 115 casualties in 1887 and 124 casualties in 1897 by fires in theaters in France.

In the 20th Century, the construction industry has developed larger and higher buildings that involve various uses in the one building. The improvement in the fire code is being pushed forward.

ii) Historical Change in Japan

The modern fire code was, like other developed countries, started with the prevention of conflagration. Then fire codes on individual buildings were added to the code.

Fire prevention measures in the latter half of the 19th. century was emphasized on the realization of a city resistant to conflagration. Two large conflagrations gave the start to designate specific techniques along which buildings are formed to fire resistant construction and have fire preventive measures at windows and doors. Those requirements were introduced into the City Planning Law and the building code issued in 1919. The City Planning Law designates fire areas, and then the building code stipulates the detailed regulations of buildings in the fire areas. Requirements include the fire resistance of external walls, eaves, windows and roofs, and structural stability of floors, columns, and stairs. After the year of 1923 when a severe

earthquake hit the Kanto Region and devastated the major part of the city area with a large conflagration, the City Planning Law, additionally designated numerous number of areas as fire areas.

The fire code for individual buildings was developed after the fires in an eight-story department store, and a three-story apartment, which caused 14 casualties and 23 casualties in 1932, respectively. In 1936, a new regulation for special buildings was established to improve the evacuation system and the fire resistant construction for such buildings as schools, apartments, department stores, and garages.

To cope with the arrival of a new epoch, the Fire Service Law and the Building Standard Law were promulgated until 1950, postwar days, which enhanced the improvement in the fire codes for individual buildings. Later on the Building Standard Law and its enforcement orders were amended nine times because there were still a number of casualties by fires. Buildings were being constructed in a more highly complex manner. The amendments have introduced requirements for noncombustible interior finishes, fire separation in higher floors, and smoke-proof staircases. The amendments have been also intended to widen the types of buildings targeted.

Recent amendments of fire codes have a tendency to be focused on enlargement of target buildings for fire protection equipment such as sprinkler systems and on soft components such as management system. The amendment in 2000 was especially focused on the inducement of performance based codes for fire protection equipment, evacuation safety, and fire resistant structure. It aims to be conformable to the current times, that is, deregulation and global cooperation in this field.

Table 7.2: Amendments of the Building Standard Law in Japan

Year	Fire Resistant Construction	Fire Separation	Noncombustible Interior Finish	Evacuation Facility	Others
1950	• Fire resistant construction for special buildings	• Fire separation by area and classification of building • Definition of fire doors		• Maximum travel distance to stairs • Structure and layout of through stairs and escape stairs	
1959 (1st)	• Quasi-fire resistant construction	• Noncombustible filling at penetrated parts of fire separation	• Inducement of noncombustible interior finish		• Regulations for underground areas
1961 (2nd)	• Extending target of the special buildings		• Extending target building		
1963 (3rd)		• Fire separation for high-rise building	• Inducement of high-rise building	• Definition of smoke-proof staircase	
1969 (4th)		• Shaft enclosure • Structural requirements for fire door	• Extending target buildings • Strengthening restriction of evacuation route	• Restriction of common path of travel distance to through stairs • Extending target for escape stairs and smoke-proof staircases	• Evacuation for underground area
1970 (5th)	• Extending target of the special buildings	• Rationalization of regulations for fire separation	• Extending target, such as habitable rooms having fire equipment		• Smoke exhaust system • Elevator for firefighters • Window for firefighters • Emergency lighting apparatus
1973 (6th)		• Strengthening installment of the fire doors • Structural requirements for fire damper	• Extending target to middle and high-rise buildings	• Extending of target buildings for two through stair or more	
1987 (7th)	• Height restriction of wooden frame buildings • Fireproof walls for wooden frame buildings				
1992 (8th)	• Provision of quasi-fire resistant building				
2000 (9th)	• Inducement of verification method	• Inducement of verification method		• Inducement of verification method	• Inducement of the performance based code for fire protection equipment

Source: JICA Study Team

iii) Loss by Building Fires in Japan and in the United States of America

In Japan, both of the number of fires and the fire rate were the largest between the 1950's and the 1970's, the period of high economic growth, and have been gradually reducing since then. The total number of casualties, including those of forestry fires and vehicle fires, skyrocketed in the 1970's and reached a plateau in the 1980's. This sudden increase of casualties is largely due to incendiary suicides. Recently the number of casualties except suicides is at the same level as that of the beginning of the 1970's, apart from 1995 when the Kobe Great Earthquake occurred. This number has a tendency to decrease slightly year by year. The average area of damaged floor by a building fire has fallen off to 40 % of that of 50 years ago.

The death rate per every 1 million persons has been decreasing also in the United States of America except special years when large earthquakes occurred.

Figure 7.6: Loss by Fires in Japan and in USA

Source: 1) Fire Defense White Paper (The Fire Defense Agency) for the Data on Losses in Japan
2) Principles of Fire Protection (NFPA) for the Data on Losses in USA

Though there are still losses by fires in both Japan and the United States of America, the losses have a tendency to decrease. It is concluded that the existing fire prevention systems are effective to some extent. More than 80% of those deaths come from the fires that occurred in residential buildings, which are the majority of the number of buildings. As it would cost a lot to improve the fire prevention system in such residential buildings, and there is limited capital, it is, therefore, the first consideration to improve large-scale buildings that have possibility to cause large losses in human lives and economy. In fact, the improvement ameliorates to raise the overall fire safety level.

Table 7.3: Losses in Japan by Classification of Building (Year 2000)

Classification	No. of Fires		No. of Deaths		Damaged Floor Area		Loss	
	(case)	(%)	(person)	(%)	(m^2)	(%)	(mil. JPY)	(%)
General Dwelling	13,027	38.3	913	66.7	658,542	41.4	52,987	37.8
Multipurpose Dwelling	1,253	3.7	197	14.4	88,942	5.6	5,974	4.3
Apartment House	4,874	14.3	51	3.7	60,697	3.8	7,144	5.1
Sub-total of Residential	19,154	56.3	1,161	84.9	808,181	50.8	66,105	47.2
Others	14,874	43.7	1,207	15.1	782,440	49.2	73,800	52.8
Total	34,028	100.0	1,368	100.0	1,590,621	100.0	139,905	100.0

Source: Fire Defense White Paper (The Fire Defense Agency)

(3) Fire Safety Level in Foreign Countries

In every country, the fire code reflects the socioeconomic background and the experiences of fire in the past. It is useful to discuss fire losses and public fire services in different countries and main cities.

The fire rate per 10 thousand population is 64.8 cases in the United States and 69.4 cases in the England, while it is only 4.9 cases in Japan. This large difference comes from statistical reasons, such as the definition of fire. The death rate per 100 thousand population is the smallest in Australia (0.61 casualties), and varies up to 1.60 casualties in Japan. The ratio of loss amount to GDP varies from 0.03% in Japan to 0.11% in the England. There is not a big difference between the four countries for the death rate and the ratio of loss amount to GDP, which means the fire safety levels of the four countries are at the same level.

The population and the energy consumption is remarkably large in Japan and in the England. The United States has a small population density and very large energy consumption. Australia has small values for both population and energy consumption.

The number of fire engines and fire stations per 10 thousand population are the largest in the United States which has a huge energy consumption and a small

population density. Those numbers in Japan rank above the England. Energy consumption and population density in Japan also exceeds those of the England.

It is considered that every country manages its own fire prevention systems according to the population density, GDP, energy consumption, public fire services, etc. and consequently there is no remarkable difference in fire safety level between the four countries.

Table 7.4: Fire Loss and Public Fire Service in the Four Countries

Items	Japan	Ratio to JPN	United States	Ratio to JPN	England	Ratio to JPN	Australia	Ratio to JPN
1 Losses								
1.1 No. of Fires (1000 cases)	62.5*[2] (00) ((34.0))	1.0	1,823.0*[3] (99) ((523))	29.2	390.8*[3] (92)	6.3	N/A	-
1.2 Fire Rate (case/10 thousand pop)	4.92	1.0	64.78	13.2	69.35	14.1	-	-
1.3 No. of Casualties (person)	2,034*[2] (00)	1.0	3,570*[3] (97)	1.8	605*[3] (97)	0.3	110*[4] (97)	0.1
1.4 Death Rate (person/100 thousand pop)	1.60	1.0	1.27	0.8	1.07	0.7	0.61	0.4
1.5 Ratio of Loss to GDP (%)	0.03*[2] (00)	1.0	0.10*[3] (99)	3.3	0.11*[4] (97)	3.7	0.16*[4] (Avg 95-97)	5.3
2 Public Fire Service								
2.1 No. of Firefighters (1000 persons)	154.0*[2] (01) ((944.1))	1.0	261.8*[3] (91) ((771.8))	1.7	35.2*[3] (98) ((14.6))	0.2	N/A	-
2.2 No. of Firefighters (persons/10 thousand pop)	12	-	9	-	6	-	N/A	-
2.3 No. of Fire Engines (vehicle)	23,064*[2] (01)	1.0	69,150*[3] (91)	3.0	2,471*[3] (91)	0.1	N/A	-
2.4 No. of Fire Engines (vehicle/10 thousand pop)	1.8	-	2.5	-	0.4	-	N/A	-
2.5 No. of Fire Stations (station)	6,291*[2] (01)	1.0	46,950*[3] (91)	7.5	N/A	-	N/A	-
2.6 No. of Fire Stations (station/10 thousand pop)	0.5	-	1.7	-	N/A	-	N/A	-
3 Country Profile								
3.1 Population (10 thousand pop)*[6]	12,692.6 (00)	1.0	28,142.2 (00)	2.2	5,635.2 (99)	0.4	1,789.2 (99)	0.1
3.2 Population Density (person/km^2)*[6]	335.9	1.0	28.2	0.1	232.0	0.7	2.3	0.0
3.3 GDP (bil. $) *[7]	4,764.0 (00)	1.0	9,963.1 (00)	2.1	1,417.4 (00)	0.3	381.8 (00)	0.1
3.4 Energy Consumption*[5] (incl. solid, liquid, electricity: mil. ton)	462.0 (98)	1.0	2,091.7 (98)	4.5	232.7 (98)	0.5	25.0 (98)	0.1
3.5 Energy Consumption (thousand ton/10 thousand pop)	36	-	74	-	41	-	14	-

Source: 1-Ministry of Home Affaires, Thailand、*2-"Fire Defense White Paper"、*3-Architecture Center、*4-The International Association for the Study of Insurance Economics, The World Fire Statistics, 2000、*5-United Nations, Energy Statistics Yearbook 1998、*6-United Nations, Demographic Yearbook 1999、*7-International Monetary Fund, International Financial Statistics Yearbook 2001、*8-United Nations/Economic Commission for Europe, Annual Bulletin of Housing and Building Statistics for Europe and North America, 2000、*9-Metropolitan Fire Brigade (Thailand), Annual Report 2001、*10-National Economic and Social Development Board (Thailand)Economic Statistics、*11-Statistical Dept. Administrative Agency, " Statistical Yearbook 2002"

Note: Years are shown in A. D. in ().
Numbers in (()) of "Number of Fires" shows the one of building fires.
Numbers in (()) of "Numbers of Fire Fighters" shows the one without contingent workers

Comparing the losses, the public fire services, and the profile between the three cities below, it is found that every city establishes appropriate fire prevention systems to keep the fire safety level within some acceptable level, according to the socioeconomic conditions of the city, in the same manner as the nation.

Death rate per 100 thousand population varies from 1.15 persons in Tokyo to 1.52 persons in New York City. Tokyo is most densely populated with 12,754 persons/km^2. Then New York City and London come with 9,004 persons/km^2, 4,449 persons/km^2, respectively. However Tokyo is ranked 1st. in the number of firefighters and fire engines (per 10 thousand population).

Table 7.5: Fire Losses and Public Fire Services in Major Cities

Items	Tokyo (23 wards)		New York		London	
		Ratio to TKY		Ratio to TKY		Ratio to TKY
1 Fire Loss						
1.1 No. of Fires (case)	4,978*[2] (00)	1.0	81,930*[2] (99)	16.5	55,679*[3] (95)	11.2
1.2 Fire Rate (case/10 thousand pop)	9.29	1.0	109.24	11.8	78.75	8.5
1.3 No. of Casualties (person)	91*[2] (00)	1.0	114*[2] (99)	1.3	86*[3] (94)	0.9
1.4 Death Rate (person/100 thousand pop)	1.15	1.0	1.52	1.3	1.22	1.1
1.5 Ratio of Loss Amount to GDP (%)	0.02	1.0	N/A	-	N/A	-
2 Public Fire Service						
2.1 No. of Firefighters (person)	18,013*[2] (99)	1.0	15,198*[2] (99)	0.8	6,000*[3] (98)	0.3
2.2 No. of Firefighters (person/10 thousand pop)	22,744	-	20,264	-	8,487	-
2.3 No of Fire Engines (vehicle)	355*[2] (01)	1.0	210*[3]	0.6	237*[3]	0.7
2.4 No of Fire Engines (vehicle/10 thousand pop)	0.45	-	0.28	-	0.34	-
2.5 No. of Fire Stations (station)	58*[2] (01)	1.0	N/A	-	113*[3]	1.9
2.6 No. of Fire Stations (station/10 thousand pop)	0.07	-	N/A	-	0.16-	-
3 City Profile						
3.1 Population (10 thousand pop)*[6]	792*[2] (99)	1.0	750*[2] (99)	0.9	707*[6] (96)	0.9
3.2 Population Density (person/km^2)*[6]	12,754	1.0	9,004	0.7	4,449	0.3

Source: *1-Statistics of the Ministry of Interior、*2-Fire Defense White Paper、*3-Information by the Building Center of Japan、*4-The International Association for the Study of Insurance Economics, The World Fire Statistics, 2000、*5-United Nations, Energy Statistics Yearbook 1998、*6-United Nations, Demographic Yearbook 1999、*7-International Monetary Fund, International Financial Statistics Yearbook 2001、*8-United Nations/Economic Commission for Europe, Annual Bulletin of Housing and Building Statistics for Europe and North America, 2000、*9-Metropolitan Fire Brigade (Thailand), Annual Report 2001、*10-National Economic and Social Development Board (Thailand), *11-Statistics 2002, Statistics Bureau, Ministry of General Affairs

Notes: Number in () is the year of the Christian era.

CHAPTER EIGHT:
FIRE CODES AND FIRE PROTECTION SYSTEMS IN THAILAND

8.1 EXISTING FIRE CODES IN THAILAND

8.1.1 Ministerial Regulations under the Building Control Act

(1) General

In 1993, Ministerial Regulation No. 33 was first issued to regulate the fire protection system of buildings. Since then, six Ministerial Regulations (MR's) have been promulgated to strengthen the requirements of the fire protection systems.

The MR 33 was legislated to stabilize the requirements for fire protection systems, building service equipment, and provide controls, such as total floor ratio and building coverage ratio of high-rise buildings (higher than 23m) and extra large buildings (larger than 10,000m^2 in the total floor area). In 2000, MR 50 was issued to further clarify the requirements of MR 33 and to add the necessity of smoke control system at atriums opening two floors or more.

The regulations MR 39 (1994) and MR 55 (2000) aim at regulating the fire protection systems of the buildings excluded from the MR 33. Regulation MR 39 specifies fire protection equipment of fire alarm systems, emergency lighting, exit signs, and emergency power supply units, while MR 55 regulates passive fire protection system of the fire resistant construction and escape stairways.

The regulation MR 48 was issued in 1997 to regulate the structural stability of principle structures through the fireproof covering and fire resistant rating of reinforced concrete and steel structures. It aims to reflect the experiences of a large fire in a doll factory in 1993 where buildings were collapsed by the fire.

On contrary to the MR's above-mentioned, MR 47 (1997) aims to improve the fire protection system of existing buildings having four stories, height of 23m, or 10,000m^2 in total floor area. MR 47 regulates the improvement of escape stairways, portable fire extinguishers, and fire alarms, etc.

Table 8.1: Ministerial Regulations for the Fire Protection System

MR	Year of Issue	Subject
No. 33	1992	• Requirements for high-rise buildings (higher than 23m) and extra large buildings (larger than 10,000m^2). • Area based controls including total floor ratio and building coverage ratio, etc. • Building service facilities including solid disposal, water supply, sewerage, drainage, power supply and elevator systems. • Fire protection system including fire resistant materials, evacuation facilities, smoke control system, fire extinguishing equipment, and supporting system for fire fighting.
No. 39	1994	• Requirements of bathrooms and lavatories, lighting equipment, and ventilation systems of residential and assembly buildings. • Fire protection systems including fire alarms, portable fire extinguishers, emergency lighting, emergency power supply units, and exit signs.
No. 47	1997	• Improvement of fire protection system of existing buildings including high-rise, extra large, large, buildings • Installment of fire alarms, portable fire extinguishers, and evacuation facilities, etc.
No. 48	1997	• Fire resistance of principle structure for buildings having special uses and scales.
No. 50	2000	• Amendment of the fire protection system specified in the MR 33.
No. 55	2000	• Set back, building material, form of habitable room, and are based control for low-rise buildings. • Fire prevention systems including escape stairways and fire resistant construction, etc.

Source: JICA Study Team

(2) Structure of the Ministerial Regulations and Other Fire Codes

Requirements of the fire protection system are specified in the Building Control Act and the Ministerial Regulations. The MR's cover the requirements to coordinate with other laws and regulations, such as the Condominium Act, the Factory Act, and the standards of the Metropolitan Electricity Authority and Provincial Electricity Authority. The related laws and regulations complement the definition and technical standards of the MR's. However, the relationship with the EIT standard and the Fire Prevention and Fire Fighting Act is not established.

Though MR 48 induces a testing standard of the American Society for Testing and Materials (ASTM), it does not specify any reliable institute to carry out the testing.

Every MR individually regulates the comprehensive requirements of specific buildings classified by the size and use of buildings.

(3) Classification of Building

The MR's classifies the type of buildings into 15 groups by building use and 3 groups by the size of buildings. The classification of building by use is subdivided into 13 single building uses and 2 multipurpose uses. The classification by size consists of high-rise, large, and extra large. The multiple classification and the classification by size aims to define a building demanding the special measures for fire safety.

Among the 13 single building uses, residential share 7 groups: Dwelling Building, Row Building, Row Brick Building, Row House, Twin House, Condominium, and Collective Dwelling Building. The classification of building other than residential is composed of commercial, office, warehouse, factory, theater, hotel, and restaurant. The building uses of educational and institutional are included in the assembly, which covers most building uses.

In general, the definitions are regulated by the 'purpose of a building' in fire codes in other countries. However, the definition of the building uses in MR's is based on the function, structure, form, and layout of a building. It also reflects the definition of other laws. Those definitions seem to cause insufficient clarity of the MR's that is also seen in the following definition.

- Difference of a row building and a row brick building is whether fire resistant materials are used.
- Difference of a collective dwelling building and a condominium is whether the building is subjected to the Condominium Act.
- Definition includes the number of stories for a row house and the access and form of a twin house.

The definition of a 'theater' is inconsistent in MR 48 and MR 55. The former specifies the theater to be used for entertainment upon a special precaution against the disaster, which is not specified in MR 55.

The definition for the classification of buildings is fundamental to properly enforce fire codes without any misunderstanding. It is desirable to amend the definition for clear classification.

Table 8.2: Classification of Building

Demarcation		Classification	Definition
By Use	Single Classification	1) Dwelling building	• Row or more than two units, with walls divided into separated units, and mostly constructed by non-fire resistant materials.
		2) Row building	• Row or more than two units, with walls divided into separated units, and mostly constructed by fire resistant materials.
		3) Row house	• Row or row brick building having an open space in front and at the rear and not more than 3 stories.
		4) Twin houses	• Dwelling building as twin house with a wall dividing the building into two houses, having open spaces in front, at the rear and the side. Each house has an individual access.
		5) Commercial building	• Building used for commercial, business, or industrial, and using the machinery with production capacity less than 5 horse power. The building has a distance not more than 20m from a road and public way.
		6) Condominium	• Building under the law-governing condominiums
		7) Collective dwelling building	• Building or any part of a building used for dwelling by several households and divided into separate units for each household.
		8) Office	• Building of any part of a building used for offices or working premises.
		9) Warehouse	• Building or any part of a building used for storing goods or articles for commercial or industrial purposes.
		10) Factory	• Building or any part of a building used as a factory in accordance with the law-governing factory.
		11) Theater	• Building or any part of a building used for showing movie, performing play, concert or other form of entertainment.
		12) Hotel	• Building or any part of a building used as a hotel in accordance with a law-governing hotel.
		13) Restaurant	• Building or any part of a building used for selling food or beverages, with an area for setting tables for serving; inside or outside the building.
	Multiple Classification	1) Assembly	• Building used for congregation of the general public for the activities concerning government services, politics, education, religion, social, recreation or commerce, such as theatre, convention hall, hotel, hospital, educational premises, library, outdoor sports field, indoor sports field, market, department store, shopping center, entertainment premises, airport, tunnel, bridge, car parking building, vehicle station, dock, landing pontoon, cemetery, crematorium, religious premises.
		2) Special Building	• Building requiring special standards of sturdiness and safety.
By Size		1) High-rise	• Higher than 23m
		2) Large	• Larger than 2,000m^2 in total floor area, • Higher than 15m, larger than 1,000m^2 and less than 2,000m^2 in total floor area.
		3) Extra Large	• Larger than 10,000m^2 in total floor area

Source: JICA Study Team

(4) Requirements for Necessity and Installment of the Fire Protection System

The MR's specify both the installment standard (the necessity of the fire protection system), and the technical standard (how to install the fire protection system). Although the installment standard covers the whole fire protection system to reflect the concept and necessity of a fire protection system, there are some which do not have the requirements of a full technical method.

For example, MR 33 imposes the necessity of an automatic sprinkler system to install in any part of the whole building, but it does not specify the technical standards to regulate any part excluded from required area, the interval, and the type of sprinkler system. Consequently, the technical judgment is left to a building official and a building engineer.

Regulation MR 48 specifies the fire resistant rating of 2 hours for floors and 3 hours for columns and walls. Such, the MR's uniformly specify requirements. The proper fire resistant rating according to the scale of a building is not taken into account.

(5) Specification and Performance based Codes

The MR's mainly adapt by specification based codes. The requirements by the performance based code are to regulate the permissible time for evacuation and the fire resistant rating of structures.

The permissible time is regulated to within 1 hour in MR 33. The fire resistant rating employs the fire testing by a reliable institute that has an authority to issue certificates for the compliance of the materials. However, the verification method for the permissible time and the reliable institute are not specified, which loses the enforcement of the MR's.

(6) Requirements on Special Buildings and Technologies

There is no criterion for special buildings and technologies which are not assumed by the requirements of the MR's. Upon the issuance of a new MR, the technical support by experts and a reliable institution is necessary for proper technical assessment in the building permissions to cope with those special buildings.

(7) Alleviation and Trade-off

The MR's have no criterion for the alleviation and trade-off between fire protection systems. Upon the issuance of a new MR, the alleviation and trade-off is necessary to mitigate the excessive requirements, if purpose of fire protection system newly introduced by the amendment overlaps that of fire protection system required in existing MR's.

8.1.2 Technical Requirements for the Fire Protection System

(1) Ministerial Regulations No. 33 and No. 50 for High-rise and Extra Large Buildings

Regulations MR 33 and MR 50 specify the requirements of the fire prevention systems for extra-large and high-rise buildings. In the prevention of the initial fire development, it regulates the installing of fire protection equipment, such as fire alarms, portable fire extinguishers, and sprinkler system. However, there is no technical standard to properly install this equipment. The technical standard for the sprinkler system has to include the intervals of sprinkler head, the required water volume, the water pressure, the required duration, and associated apparatus, such as a water pump and a water tank. Moreover, it is necessary to also the types of detectors and fire alarms.

In the prevention of fire spread, MR 33 prescribes a 1-hour fire resistant rating of walls, fire doors, air-conditioning ducts, and garbage shafts. In addition, the fire damper of 1-hour fire resistant rating is specified for the air-conditioning with heat detectors. Though the minimum thickness of the fire resistant wall is set in the requirement, the MR's do not cover the specification of fire doors and fire dampers.

Regulation MR 33 specifies the necessity of two escape stairways or more within a distance of 60 m from any part of a building. It covers most of the requirements for evacuation facilities, except the maximum common path of exit access travel.

The MR 33 regulation also includes some unsuitable and insufficient requirements.

- Prevention of smoke intrusion into an escape staircase is formed by installing, in front of the staircase, a balcony or a vestibule having a fire door and a smoke control system, though the MR requires the control of the smoke by pressurizing within the staircase or exhausting from the staircase. The pressurized system within the fire staircase may bring disadvantages: unreliability by continuous opening of doors by building users in case of a fire, high construction cost to pressurize the whole staircases, and the requirement for precise construction work for high air-tightness. The exhausting from the staircase may allow smoke intrusion, due to the decompression in the staircase.
- The MR regulates the width of an escape stairway to at least 90cm which should be based on the number of occupants who have to pass through the escape stairway.
- The requirements do not cover the verification method for estimating the required time of evacuation, though the MR regulates the evacuation time to within 1 hour.

In the support for fire fighting, MR 33 covers the necessary facilities for the access and supporting equipment of the fire fighting, except for the requirements for a fire

fighting control room, emergency power supply unit, and window for firefighters. It also has an insufficiency of technical standard, such as the dimension and velocity of an elevator for firefighters.

By and large, MR 33 focuses on the fire protection equipment necessary for the stages from the prevention of initial fire development to the support for fire fighting. In other words, the requirements mainly consist of the active system, though the regulated passive system covers only an escape stairway, fire door, and fire resistant wall. Moreover the technical standard is insufficiently specified in MR 33.

Table 8.3: Technical Requirements of the Ministerial Regulation No. 33 and No. 50 (1/2)

Fire Protection System		High-rise	Extra Large
Prevention of Initial Fire Development			
Fire Alarm	• Install at every floor	○	○
	• Signal and sound type, operated automatically and manually	○	○
Portable Extinguisher	• (if fire hose cabinet and outside hydrant are not installed.)	○	○
	• Install at every 45m in distance and at least one piece per 1,000m^2	○	○
	• Chemical content more than 4kg	○	○
Sprinkler	• Install at every floor	○	○
Power Supply System	• Distribution system according to MEA and PEA	○	○
	• Special room for transformer, generator, and main switch with automatic emergency power supply system.	○	○
	• Capable for operating for more than 2 hours for lighting in escape stairways, evacuation routes, lobbies, and exit signs, fire alarms, elevators for firefighters, fire fighting pump, fire fighting control room, and communication room.	○	○
Prevention of Fire Spreading			
Wall and Door	• Fire resistant materials to stand for more than 1 hour.	○	○
Air Duct	• Fireproofing inside and outside of the duct	○	○
	• No usage of material causing smoke	○	○
	• Closing valve at penetrating part of fire wall and floor, which is fire resistant for 1.5 hour and automatically closes, if temperature is more than 74℃	○	○
	• Install manual switch	○	○
	• Prohibited to install air duct at staircase, elevator shaft except behind ceiling having fire resistant rating more than 1.5 hours	○	○
	• Install smoke detector and fire detector, if ventilating more than 50m^3/min	○	○
EV Shaft	• Prohibited to install facilities, such as wires, water pipes, and drainage except parts of elevators.	○	○
	• Install mechanical ventilation to keep air pressure at 38.6P in the shaft	○	○
Dust Chute	• Fire resistant wall	○	○
Evacuation			
Escape Stairway	• Continuous from the top floor or roof to the ground floor	○	-
	• Complete evacuation within one hour	○	-
	• Two stairways or more at every 60m in distance	○	-
	• Fire resistant wall and steps	○	-
	• Min. width 90cm, min. tread 22cm, and max. rise 20cm	○	-
	• Width of landing more than 90cm	○	-
	• Install handrails at both sides and lighting by emergency power supply	○	-

Table 8.3: Technical Requirements of the Ministerial Regulation No. 33 and No. 50 (2/2)

Fire Protection System		High-rise	Extra Large
Evacuation			
Escape Stairway	• Install ventilation of inhaling openings with more than 1.4m^2 at every floor or air pressure system to keep more than 38.6P, automatically started up in emergency	○	-
	• Indication of floor number and direction	○	-
	• Directly connected to outside	○	-
Outside Escape Stairway	• Fire resistant wall	○	○
Escape door	• Fire resistant material	○	○
	• Net area of a door more than 1.9m by 0.9m	○	○
	• Open to outside with automatic door closer	○	○
	• No step in front of an escape stairway	○	○
Void (more than one floor without any wall)	• Install smoke control system to quickly exhaust out smoke to the outside	○	○
	• Start up automatically, when a fire breaks out	○	○
EV hall	• Install a map indicating hose reel, valve, fire door, escape stairways, and elevator for firefighters	○	○
Rooftop Safety Area	• More than 10m^2	○	-
	• Access with escape stairways	○	-
	• Install equipment and devises to escape safely to the ground.	○	-
Fire Fighting and Rescue			
Elevator for Firefighters	• Install main switch separately in the special room	○	○
	• Protect electric circuit from a fire	○	○
Life Lobby for Firefighters	• An area of more than 6m^{2}at every floor with	○	-
	• Adjacent to an EV for firefighters and escape stairways	○	-
	• Protect from a fire and smoke.	○	-
Indoor Fire Hydrant	• Install a fire hose cabinet near escape stairways at every floor	○	○
	• Diameter is 25mm for coupling and 65mm for quick coupling	○	○
	• Install at every 64m in distance	○	○
	• Length of hose less than 30m	○	○
Water Tank for Fire Fighting	• Water pressure at the top floor varies 0.45-0.7MP	○	-
	• Min. supplied water volume is 30l/s.	○	-
	• Install automatic pressure control valve	○	-
Water Supply pipe	• Allowable pressure more than 1.2MP	○	○
	• Connection from the top floor to the lowest floor	○	○
	• Connection with main supply pipe in a building, and with transmission pipe for outside hydrant.	○	○
Outside Fire Hydrant	• Diameter is 65mm for quick coupling	○	○
	• Capacity of receiving tank is for 30minutes	○	○
	• Supplied water for the first hydrant is 30l/s and 15l/s for others. Totally 95l/s.	○	○
Open Space for Fire Fighting	• Open space or road with no covering around a building with 6m in width	○	○
	• Setback of 6m from other plots and public road	○	○
	• Access to a public road of 18m width by 12m in length or 18m public road by 12m access road for a building with more than 3,000m^2 in total floor area.	○	○
	• Access to a public road of 10m width by 12m in length or 10m public road by 10m access road for a building with less than 3,000m^2 in total floor area.	○	○

Note: Fire resistant material means non-combustible materials.
Fire resistant wall means: 1) solid brick wall with 18cm thick, 2) solid wall having fire resistant more than solid brick wall, and 3) reinforced concrete wall more than 12cm thick.

Legend: ○: specified, -: not specified.

(2) Ministerial Regulation No. 39 for Fire Protection Equipment

Regulation MR 39 focuses on the fire protection equipment, such as portable fire extinguishers, fire alarms, exit signs, emergency lighting, and emergency power supply. These fire protection systems are meaningful to strengthen the fire safety for the prevention of initial fire development and evacuation of a building that is outside of the targeted buildings in MR 33.

However, similarly to MR 33, MR 39 is insufficient for the technical standards of the required fire protection systems. For example, the technical standards have to cover the following requirements.

- Type of fire extinguishing agents for the portable fire extinguisher, according to types of uses and hazardous materials in rooms.
- The type of detectors and the linkage with the detectors for the fire alarm suitable for characteristics of rooms.
- The intensity of illumination and the type of power supply for the emergency lighting.

Table 8.4: Technical Requirements in the Ministerial Regulation No. 39

Fire Protection System		Classification of Building							
		Row room	Row room brick	Row house	Complex house	Public		Common house > 4 units	Building >3stories
						Shop house, Parking lot, Shopping center, Service, Educational, Library, Airports, Parking building, Harbor, Restaurant, Government office	Indoor sports stadium, Market place, Department store, Mass transit terminal, Office, Factory, Theater, Meeting hall, Hotel, Medical treatment		
Portable Extinguisher	Per room or unit for 1 or 2 story building.	○	○	○	○				
	Per room or unit for more than 2 story building	○	○	○	○				
	Per 1,000m^2 and at every 45m on every floor					○	○	○	○
Fire Alarm	Per room or unit.	○	○	○	○				
	Per room or unit on every floor	○	○	○	○				
	On every floor for buildings > 2,000m^2					○	○	○	○
Exit Signs, Floor Number, and Emergency Lighting	More than 2 story building.					○	○	○	
	More than 2,000m^2 in total.								○
Emergency Power Supply	Automatic supply						○		
	2hours supply for fire alarm, exit sign of evacuation route, and escape stairway						○		
	Supply for operational period of ICU, CCU, elevator for firefighters, life saving room, communication system, fire pumping, industrial						○		

Note: Alarm is signal and sound type.
Legend: ○: specified, -: not specified.

(3) Ministerial Regulation No. 47 for Improvement of Existing Buildings

Regulation MR 47 aims to strengthen the fire protection system of existing buildings. It focuses on the prevention of initial fire development and the evacuation by the following six elements.

- Fire alarm with automatic and manual devices and capable of sending the signal.
- Portable fire extinguisher per 1,000m^2 within every 45m distance.
- Escape stairways capable to allow 1-hour evacuation of a whole building.
- Installation of a sign of the floor layout, indicating habitable rooms, portable fire extinguishers, and escape stairways, in front of an elevator.
- Emergency lighting.
- Lightning protection.

In practice, every existing building has an unique floor layout of which some is not suitable for modification to comply with the requirements above-mentioned. Therefore the retroactive requirements to existing buildings have to involve some flexibility to allow adaptation to the existing situation. For instance, an escape staircase enlarged in width, or newly constructed, may deconstruct a principle structure of an existing building.

(4) Ministerial Regulation No. 48 for Fire Resistant Construction

Regulation MR 48 aims to specify the fire resistance of the principle structure of a building that has 1,000m^2 or more in total floor area and 4 stories or more height, and which has specific building uses, such as theaters, hotels, residential, etc. The principle structure is defined as columns, beams, floors, and evacuation facilities.

It specifies the fire resistant rating of 3 hours for the columns and beams and 2 hours for floors. The fire resistant rating is deemed to be satisfied by complying with the minimum thickness of fireproofed covering. If the structure does not meet the minimum thickness, the certification of fire testing according to ASTM E 119 (Standard Test Methods for Fire Tests of Building Construction and Materials) by a reliable institute is necessary.

However, MR 48 has the following deficiencies.

- The fire resistant rating is excessive, as the 3-hours and 2-hours rating are applied to the highest standard in other countries where fire resistant rating adopt a range from one to three hours depending on the scale of the building.
- The definition of what constitutes a reliable institute is not specified.
- The fire testing standards of other countries are not suitable to conform to the

international harmonization of standards, moreover every national standard reflects the socioeconomic situation of the country for which it was developed.

Table 8.5: Technical Requirements in the Ministerial Regulation No. 48

Target Building	Requirement
More than 3 floors	Principal structure (columns, beams, floor) and escape facilities are noncombustible materials.
Warehouse, theater, hotel, condominium, and medical treatment	Principal structure shall be constructed with fireproof materials of RC covering as shown below. (Type of Principal Structure) (Minimum Thickness of RC) 1 Reinforced concrete 20 - 40 mm in minimum 2 Pressed concrete 20 - 115 mm in minimum 3 Profile steel framework 25 - 50 mm in minimum
More than 3 floors and total area of more than 1,000m2 for specific building uses*[1]	
High-rise, extra large, large, and meeting hall	

Note: *[1] - Commercial, industrial, educational, public health, and office.

(5) Ministerial Regulation No. 55 for Escape Stairways and Fire Resistant Construction

Regulation MR 55 focuses on strengthening the fire resistant construction and escape stairways of a building smaller than the high-rise and extra large buildings subjected to MR 33.

The Regulation specifies the fire separation by a fire wall to divide a residential building into a set of five housing units and the fire resistant wall and floor for a kitchen. As for the evacuation, although the requirements require one escape stairway, there is no requirement for its layout and capacity sufficient for the number of occupants.

Table 8.6: Technical Requirements in the Ministerial Regulation No. 55 (Structure)

Requirement	Classification of Building				
	Building more than 3 stories	Specific building	Row brick and row house building	Row, row brick, and row house building	Kitchen
Fire resistant materials for column, stairway, and floor	○	○			
Fire resistant materials for wall, such as normal brick or no-reinforced concrete with more than 8cm in thickness			○		
Fire resistant wall and top deck				○	
Fire resistant wall dividing a dwell building into 5 units or less.				○	
Fire resistant wall higher than the roof level by 30cm, if roof is non-fire resistant.				○	
Fire resistant materials for floor and wall					○
Fire resistant materials or lined with fire resistant materials for ceiling					○

Note: Specific building includes theater, convention hall, factory, hotel, hospital, library, department store, large, service, and airport.

Legend: ○: specified

Table 8.7: Technical Requirements in the Ministerial Regulation No. 55 (Escape Stairway)

Requirement	Classification of Building	
	Building more than 4floors and less than 23m	Three-story building with top deck over 16m
At least one escape stairways additionally to the normal stairs*[1]	○	○

Note: *1- Requirements for the escape stairway is 1) made of fire resistant materials, 2) min. 80cm in width, 3) with lighting and ventilation from outside with opening more than 1.4m^2, 4) with fire doors with a size of more than 0.8m x 1.9m, opened to outside, door-closer, 5) no obstructs and steps to the stairway, 6) min. width of corridor more than stairs, 7) in a case of outside stairs, made of fire wall and min. width is 60cm. Metal sliding stair be installed, if not accessed to the ground floor.

Legend: ○: specified

(6) Fire Protection System in the Ministerial Regulations

In summary of the examination of the MR's mentioned above, the required fire protection presents a tendency that is focused on the evacuation, support for fire fighting, and prevention of building collapse rather than the prevention of fire development from the outbreak of fire to the fire spread.

The insufficient requirements of the former three categories are summarized in the following lists.

- Maximum common path of exit access travel and the smoke-proof staircase for the evacuation.
- Supporting system for radio communication and the fire fighting control room for the fire fighting.

Among the latter fire protection systems, the prevention of fire spread is typically insufficient in that there is no requirement for the following four types of fire separation: Area separation, Vertical opening protection, Mixed use separation, and Separation in incidental use area. Consequently the MR's have no requirement for the protection at openings and at penetrated parts of the structure forming the fire separation.

The fire protection systems emphasize the active systems rather than the passive systems consisting of fire separation, noncombustible interior finish, and smoke proof staircases. The insufficiency in these passive systems may allow large fire losses as illustrated below.

- After the outbreak of fire, the fire may rapidly develop and spread over the surface of the combustible interior finish. A fully-developed fire in a room spreads to other rooms and floors in the early stage of the fire development, due to the lack of fire separation. A combustible interior finish may generate a large volume of smoke and toxic gas, which obstruct evacuation routes and enter into escape staircases. The occupants in the building lose evacuation routes due to smoke being present in evacuation routes and escape stairways, and are affected

by the toxic gases. Moreover, in some situations, the rapid fire development can spread out of control by fire fighting.

On the other hand, passive system have the advantage of higher reliability than a active system. It is fundamental to secure the fire safety to the permissible level by a passive system and to raise this level by the active system.

The technical standard has many deficient points. For example, although the necessity of installment of a sprinkler system is imposed, the detailed requirements are not specified to maintain its effectiveness by proper design. The defects within the technical standard is common also to other fire protection systems, such as fire alarms, exit sign illumination, fire hydrants, etc. The correct planning and design of a fire protection system is largely influenced by the discretion of building officials and building engineers.

Table 8.8: Technical Requirements in the Ministerial Regulations

Fire Protection System			MR 33	MR 39	MR 47	MR48	MR 50	MR 55	Overall
Prevention of Initial Fire Development	Detection, Alarm, and Report	Fire Alarm System	●	●	●				●
		Detection System							
	Initial Fire Extinguishing	Portable Fire Extinguisher		●	●				●
		Automatic Sprinkler System	●						●
	Noncombustible Interior Finish	at walls							
		at ceiling							
		at floor							
Prevention of Fire Spread	Fire Separation	by area							
		at vertical openings							
		by different occupancy							
		at incidental parts							
	Fire Separation at Openings	Non-combustible Fillings at Penetrated Parts							
		Fire Doors							
		Windows with Fire Resistance							
		Air Ducts and Pipes	●				●		●
		Fire Damper with Automatic Closing	●						●
Evacuation	Evacuation Planning	Multiple Evacuation Directions	●						●
		Maximum Exit Access Travel Distance	●					●	●
		Maximum Common Path of Exit Access Travel							
	Stairways	Through Stairways							
		Fire Escape Stairways	●		●			●	●
		Smoke-proof Stairways							
		Outside Fire Escape Stairways	●						●
	Exit Discharge							●	●
	Form of Doors		●		●				●
	Supporting System for Evacuation	Rooftop Safety Area	●				●		●
		Balcony Linking							
	Lighting and Exit Signs	Exit Sign	●	●	●				●
		Exit Sign Illumination							
		Emergency Lighting	●	●	●			●	●
	Smoke Control	Smoke Curtain							
		Smoke Enclosure					●		●
		Smoke Control Equipment	●					●	●
	Emergency Electricity Supply		●	●			●		●
Fire Fighting	Elevator and Life Lobby for Fire Fighters	Elevator for Fire Fighters	●						●
	Fire Plug	Indoor Fire Hydrant	●						●
		Outdoor Fire Hydrant	●						●
	Radio Communication System Support								
	Fire Fighting Control Room								
Prevention of Building Collapse	Fire Resistant Construction	Fire Resistance of Column, Beam, Stair, and Wall						●	●
		Fire Rating of Principle Structure				●			●
Prevention of Exposure Fire	Fire Resistance on External Wall and Roof							●	●

Legend: ○: specified

8.1.3 EIT Standard

(1) General

The EIT standard aims to supplement the technical standard for a fire protection system in Thailand upon introducing the fire codes of foreign countries. The Engineering Institute of Thailand (EIT) issued the 1st. edition in 1997 and the 2nd. edition was published in August 2002.

The EIT standard is devised so that it may be easy to use for the Thai engineer, such that it simplifies the fire codes of foreign countries and uses the Thai language with the metric system. Most of the standards are imported from the NFPA standard and the Uniform Building Code (UBC) of the United States of America.

(2) Structure of EIT Standard

The new EIT standard (2nd. edition) consists of five parts: Terminology, fire-resistant structure, fire protection equipment, smoke control, and evacuation. It covers the installment standard and the technical standard. Some requirements of the EIT standard adopt the reference standard further issued by the EIT, as listed below.

- Requirements for the fire alarms, lightning protection, emergency power supply, emergency lighting, and exit sign refer to further individual standards, respectively.
- A standard for mechanical conveyance system covers the public address system, emergency report system, and elevator for firefighters.
- A standard for machinery system specifies the smoke control.
- A standard for fire detector specifies the requirements for the detection and alarm systems.

(3) Classification of Building

The EIT standard defines 11 kinds of building classification. It further subdivides the classification into 40 groups, by the number of occupants, the floor area, and the hazardous materials of buildings. The basic classification consists of Assembly, Educational, Social welfare, Business, Commercial, Danger Hazardous, Industrial, Service Center, Health Hazardous, Residential, and Miscellaneous. The miscellaneous group includes civil engineering facilities and other structures.

Similarly to the MR's, the classification involves definitions by the scale of buildings: high-rise, large, and extra large.

Table 8.9: Classification of Building by the EIT Standard

Classification		Definition
Assembly	A1	Assembly room with 1,000 occupants or more and a stage
	A2	Assembly room with less than 1,000 occupants with a stage or 250 occupants without a stage
	A3	Assembly room with 30 – 249 occupants or more and a stage
	A4	Outdoor assembly area or stadium
Educational	E1	50 occupants or more
	E2	Less than 50 occupants
	E3	Pre-kindergarten and kindergarten with 30 occupants or more
Social Welfare	S1	Mental hospital, mental sanitarium
	S2	Nursing home, hospital, sanitarium
	S3	Excluding S1 an S2
	S4	Jails, prisons, etc.
Business	B1	80m2 or less for office
	B2	More than 80m2 for bank, health service, police station, etc
Commercial	C1	Wholesale and marketplace
	C2	Excluding C1
Danger Hazardous	DH1	Production of oxygen, chemical substance, flammable materials
	DH2	Manufacturing, delivering, maintaining liquid fuel, gas, match, etc
	DH3	Manufacturing, delivering, maintaining flammable materials
Industrial		Manufacturing non-explosives or non-flammables
Service Center		
Health Hazardous	HH1	More than 2 pieces of musical instruments
	HH2	Generating nuisance to neighborhood or environment
	HH3	Producing pollution to neighborhood/environment (related to Environment Act)
	HH4	Producing pollution to neighborhood/environment
Residential	R1	Temporary living
	R2	Living of multiple families
	R3	Living of Individual families
Miscellaneous	M1.1-8	Billboard or signs
	M2	Construction without occupants in the structure (pagodas)
	M3	Similar to M2 with occupants
	M4	Building with time limitation of occupation or temporary use

(4) Specification and Performance based Codes

The requirements are mainly formed by a specification based code. Parts of them are stipulated by the performance based code that, for instance, covers the fire resistant rating of structures and fire doors.

Testing standards of ASTM E 119 and BS 476 (Fire Tests on Building Materials and Structures) are, for example in MR 48, set for the verification method for the fire resistant rating. Specified testing standards include ASTM E 84 (Standard Test Method for Surface Burning Characteristics of Building Materials) and NFPA 253

(Standard Method of Test for Critical Radiant Flux of Floor Covering Systems Using a Radiant Heat Energy Source) for materials of with noncombustible finish.

As for the standard of products, pipe materials have to comply with requirements of American National Standard Institute (ANSI), American Water Works Association (AWWA), and ASTM. A hose cabinet is required to conform to EN 671-1.

However the EIT standard has no specification for a reliable organization to implement the fire testing.

(5) Alleviation and Trade-off

The EIT standard specifies alleviation by installment of a sprinkler system to mitigate the grade of structure, the grade of noncombustible interior finish, the width of evacuation routes, and the maximum exit access travel distance.

(6) Technical Requirements of EIT Standard

Based on the items of the fire protection system used for the fire codes in foreign countries, the requirements of EIT standard are examined. The EIT standard mostly covers all the fire protection requirements except that of area separation, maximum common path of exit access travel, rooftop safety area, and radio communication for fire fighting. Further to the insufficient requirements, the area separation is complemented by the separation at incidental use area that requires the fire separation between guestrooms, housing units, and tenant spaces. The 2nd. edition of the EIT standard supplements the noncombustible interior finish.

The requirement includes the installation standard and the technical standard that covers the necessary performance, layout, and detailed specification. It typically presents illustration and hydrological calculation for the sprinkler system.

Apart from the enrichment of requirements, there are inconsistencies. The definition of the classification of building is different between chapters of the terminology, the fire resistant structure and the evacuation. Due to the quotes from fire codes from foreign countries, the requirements need adjustment to agree with those in the MR's. The inconsistent requirements between the EIT standard and the MR's are listed below.

- Minimum fire resistant rating of the principle structure is set 1-hour less than the requirements of MR 48 that specifies 2-hours at least.
- Maximum exit access travel distance is regulated for offices 90m longer than in MR 33 that uniformly regulates 60m for high-rise buildings.

Table 8.10: Fire Protection System of the EIT Standard

Fire Protection System			Condition
Prevention of Initial Fire Development	Detection, Alarm, and Report	Fire Alarm System	Referred to other EIT standard
		Detection System	Referred to other EIT standard
	Initial Fire Extinguishing	Portable Fire Extinguisher	Specified
		Automatic Sprinkler System	Specified
	Noncombustible Materials for Interior Finish	at walls	Specified
		at ceiling	Specified
		at floor	Specified
Prevention of Fire Spread	Fire Separation	by area	
		at vertical openings	Specified
		by different occupancy	Specified
		at incidental parts	Specified
	Fire Separation at Openings	Non-combustible Fillings at Penetrated Parts	Specified
		Fire Doors	Specified
		Windows with Fire Resistance	Specified
		Air Ducts and Pipes	Specified
		Fire Damper with Automatic Closing	Specified
Evacuation	Evacuation Planning	Multiple Evacuation Directions	Specified
		Maximum Exit Access Travel Distance	Specified
		Maximum Common Path of Exit Access Travel	
	Stairways	Through Stairways	
		Fire Escape Stairways	Specified
		Smoke proof Stairways	Specified
		Outside Fire Escape Stairways	Specified
	Exit Discharge		
	Form of Doors		Specified
	Supporting System for Evacuation	Rooftop Safety Area	
		Balcony Linking	Specified
	Lighting and Exit Signs	Exit Sign	
		Exit Sign Illumination	Specified
		Emergency Lighting	Specified
	Smoke Control	Smoke Curtain	
		Smoke Enclosure	Specified
		Smoke Control Equipment	Referred to other EIT standard
	Emergency Electricity Supply		Referred to other EIT standard
Fire Fighting	Elevator and Life Lobby for Fire Fighters	Elevator for Fire Fighters	Referred to other EIT standard
	Fire Plug	Indoor Fire Hydrant	Specified
		Outdoor Fire Hydrant	
	Radio Communication System Support		
	Fire Fighting Control Room		Specified
Prevention of Building Collapse	Fire Resistant Construction	Fire Resistance of Column, Beam, Stair, and Wall	Specified
		Fire Rating of Principle Structure	Specified
Prevention of Exposure Fire	Fire Resistance on External Wall and Roof		Specified

8.2 ANALYSIS ON MAJOR BUILDING FIRES

The official statistics of major building fires are not readily available. Therefore we have selected case studies of two major fires that caused around or more than 100 deaths

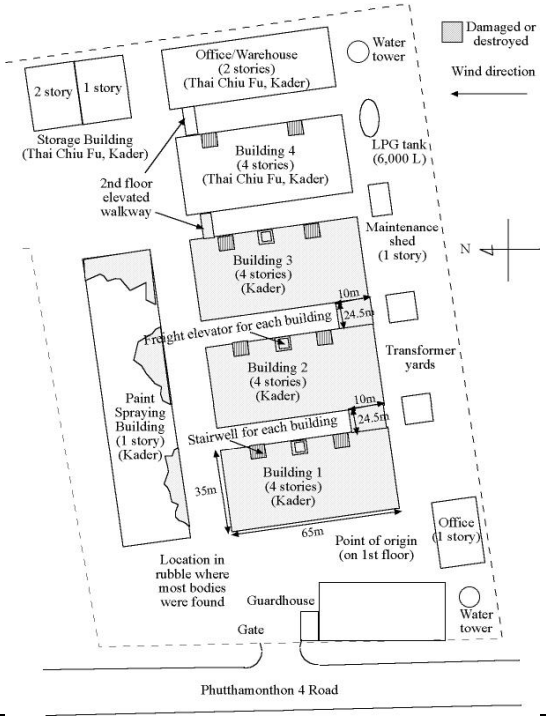
- Fire at the Kader Doll Factory which resulted in the largest number of deaths in Thailand. The fire occurred in 1993 and left 188 deaths.
- Fire at the Royal Jomtien Resort Hotel with 91 deaths in 1997.

Based on a special feature article in the NFPA journal about both fires, we analyzed the factors upon which the fire expanded.

8.2.1 Fire at the Kader Doll Factory

The blaze broke out at 4:00 am on May 10, 1993 and destroyed three factory buildings incorporating much combustible materials. The fire recorded 188 deaths and 469 injuries, of which 80% were seriously injured. These figures are still the highest toll from a fire in Thailand.

Figure 8.1:Outline of the Fire at the Kader Doll Factory

Total Floor Area	9,100m^2/building	**No. of Floors**	4 floors
Purpose of Floor	1st - 4th floor (2,275m^2/floor (35×65 m))		Factory
Structure	RC slab and steel structure with concrete block wall (7 cm)		
Staircase and Elevator	2 staircases (1.6m width) and a caged elevator assemblies		
Building Owner	Shared by Taiwan (20%), Hong Kong (79.96%), and Thai (0.04 %) companies		
Building User at the fire	2,500 workers: 1,146 workers at Building 1,405 at Building 2, and no figure for Building 3.		
No. of Deaths	188 persons	**No. of Injuries**	469 persons (heavy injuries: more than 80%)
Site Plan (Note: Plan is schematic and has no scale.)			

Source: NFPA Journal

The unsuitable construction and maintenance management by the building owner was one of the factors which caused the fire to spread. Although a fire accident had previously occurred at the same site, improvement of the maintenance and management was neglected. The building was made of a fireproof structure lower than the design at the time of building permission. When the fire broke out, the security guard who discovered the fire and unsuccessfully performed the initial fire extinguishing, was late to contact the fire department and kept the employees in the building. In addition, evacuation was hindered by the doors and windows being wired shut and the failure of the fire alarm. When the firefighters finally arrived at the site, 40 minutes after the discovery of the fire, the fire had already covered whole buildings.

Due to the physical condition of the building, the lack of the fire separation, such as the area separation and vertical opening protection, the fire was allowed to expand from the first floor to the upper floors through an elevator shaft. Since staircases were filled with smoke and flame, the employees lost the ability to use evacuation routes. The factory buildings finally collapsed due to lack of fire resistant covering on the steel structures.

Table 8.11: Problematical Issues of the Fire at the Kader Doll Factory

Fire Protection	Factor by Physical Component	Factor by Soft Component	
		Management	Reaction
Prevention of Initial Fire Development		• Malfunction of fire alarm system.	• No improvement after the fires in 1989 and 1993. • Thrown cigarette caused the fire. • Failed initial extinguishing by guards as the fire broke out in an area with a lot of combustible materials. • Late report to the fire department 20 minutes after the awareness of the fire. • Improper order by guards to employees to stay in the building.
Prevention of Fire Spread	• Fire spread from 1st to upper floors through areas without area separation or vertical opening protection. • Fire spread through elevator shafts and staircases lacking fire separation.		
Evacuation	• Staircases filled with smoke and flame.	• Doors and windows locked with wires and railings. • A lot of combustible materials in 1-m width corridors.	• Reduce of the number of exits from the plan of the building permission.
Support for Fire Fighting	• Unclear layout of outdoor fire hydrant causing delay in set-up of fire fighting.		• More than 40 minutes delay in the arrival of firefighters due to the late report and traffic congestion. • Improper coordination of hospitals to receive injuries.
Prevention of Building Collapse	• Building collapse due to no fireproof covering on steel structures.		• Modification of fireproofed steel structure to the lower level than the building permission.

Source: JICA Study Team and NFPA journal

8.2.2 Fire at the Royal Jomtien Resort Hotel

A fire broke out in a ground-floor coffee shop at the Royal Jomtien Resort Hotel at approximately 10:30 am on July 11, 1997. The fire took 91 lives and seriously injured a further 51 people.

Table 8.12: Outline of the Fire at the Royal Jomtien Resort Hotel

Total Floor Area	30.425 m^2		**No. of Floors**	17 floors (55.1 m high)
Use of each Floor	1st	A lobby, a hall, 2 restaurants, and a coffee shop	2nd	Conference room, meeting rooms
	Mezzanine	Fitness club and offices	3rd-17th	384 guestrooms
Structure	Concrete floor with concrete column. Original roof was of concrete slab and later construction was corrugated cement sheeting. Discotheque and conference rooms used unprotected steel trusses covered with metal decking (collapsed during the fire).			
Staircase and Elevator	3 staircases and 5 elevators.			
No. of Casualties	91 persons		**No. of Serious Injuries**	51 persons
Insurance	Building, furniture, and equipment were insured with Krung Thai Panich Insurance Company and Samaggi Insurance Plc for 400 mil and 105 mil Baht respectively			
Other Information	The resort was confident about the fire safety of the building because it advertised that the building had wall-to-wall carpets made of flame-retardant materials that offer both comfort and safety; smoke detectors installed in every room, and three fire exits located in the middle and at both ends of each floor in 1990.			

Source: NFPA Journal

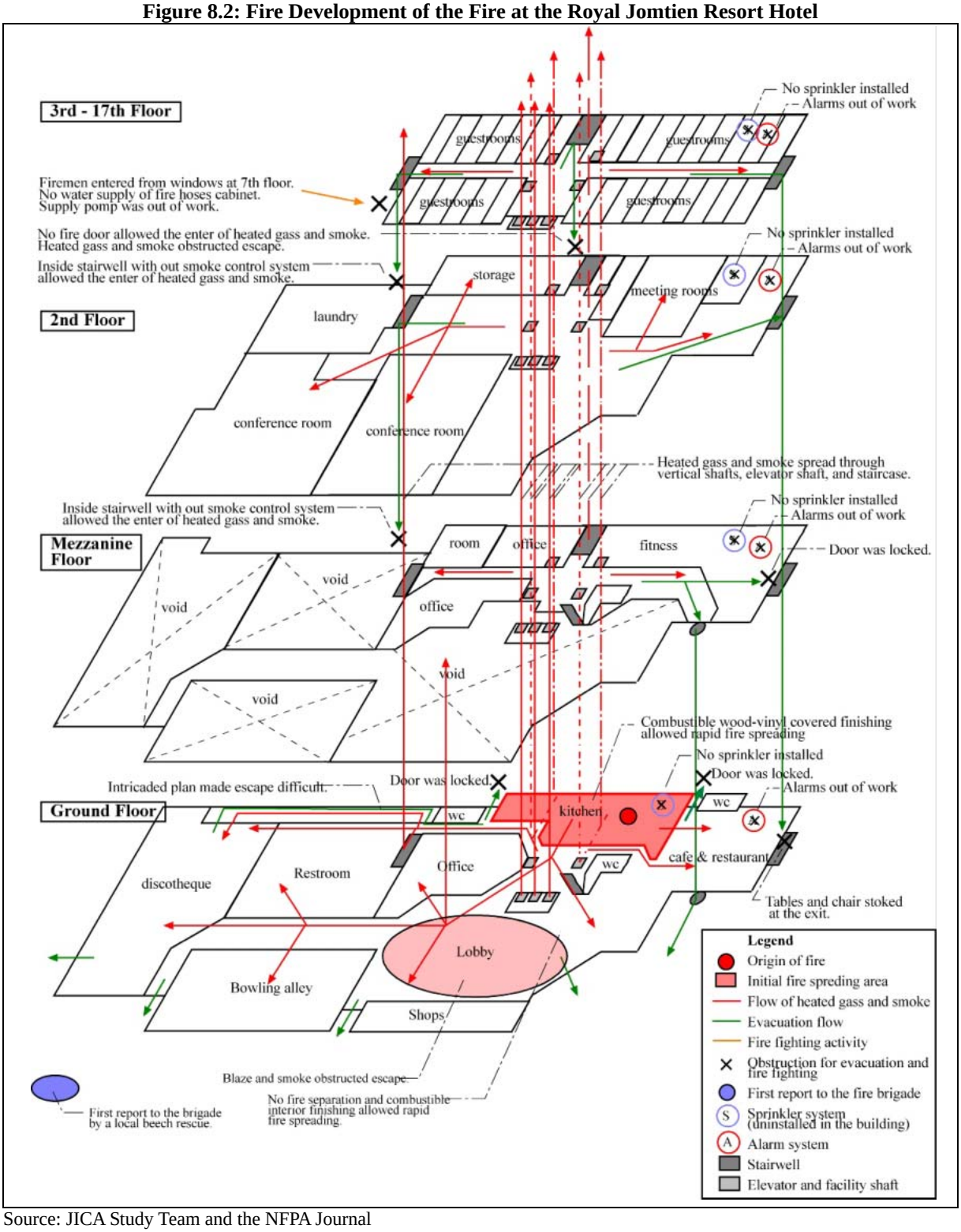
The physical condition of the building and the non-awareness of a gas leak from a cooking room, since a gas leakage detector was not installed, were factors in this fire. The flames rapidly grew and smoke spread quickly, due to the usage of combustible materials for interior finish and the lack of any fire separation. The fire expanded through an atrium and staircases of the entrance hall, an elevator shaft, and through the service shaft.

The safety of evacuation routes were not well secured, since they were complicated routes as the occupants had to pass through a restroom for access to the evacuation route. There was also an inadequacy of emergency lighting and the smoke proofing of staircases. Moreover fire engines could not approach the building due to the insufficient width around the building for the access of fire engines. The diameter of the hose connection of the building differed from that of fire engines. These improper design factors delayed fire fighting and rescue activities.

Further problems were pointed out in the management side by building administrators. The staff did not perform smooth guidance for the evacuation. There was late reporting to the fire department. The fire alarm systems were not working at that time. Miscellaneous items were stacked at outdoor escape stairways, which impeded and blocked evacuation routes. Some parts of the evacuation routes were locked.

During the stage of fire fighting, problems occurred with the breakage of the indoor fire hydrant and the failure of a fire pump. Moreover, the firefighters arrived late at the site, up to 30 minutes after the report to the fire department.

Figure 8.2: Fire Development of the Fire at the Royal Jomtien Resort Hotel



Source: JICA Study Team and the NFPA Journal

Table 8.13: Problematical Issues of the Fire at the Royal Jomtien Resort Hotel

Fire Protection	Factor by Physical Component	Factor by Soft Component	
		Management	Reaction
Prevention of Initial Fire Development	• No gas leakage detector causing late awareness of gas leak. • Usage of combustible materials for interior finish	• Malfunction of fire alarms causing the delay of initial reaction and evacuation.	• Late report to the fire department. • No guidance by staff for evacuation.
Prevention of Fire Spread	• No fire separation at vertical openings, atrium, elevator shaft, and pipe shaft which became the path of fire spread.		
Evacuation	• No smoke control causing smoke intrusion into staircases. • No automatically closing fire doors. • No emergency lighting. • Complicated evacuation routes.	• Blockage of outdoor escape stairway by miscellaneous things. • Locked outdoor escape stairway.	
Support for Fire Fighting	• Insufficient space between the building and fence obstructing the approach of fire engines. • Impossible connection of outdoor fire hydrants.	• No water resource for indoor fire hydrants. • Malfunction of a fire pump. • Breakage of indoor fire hydrants.	• Late arrival of firefighters 30 minutes after the report.
Prevention of Building Collapse	• Collapse of steel structure.		

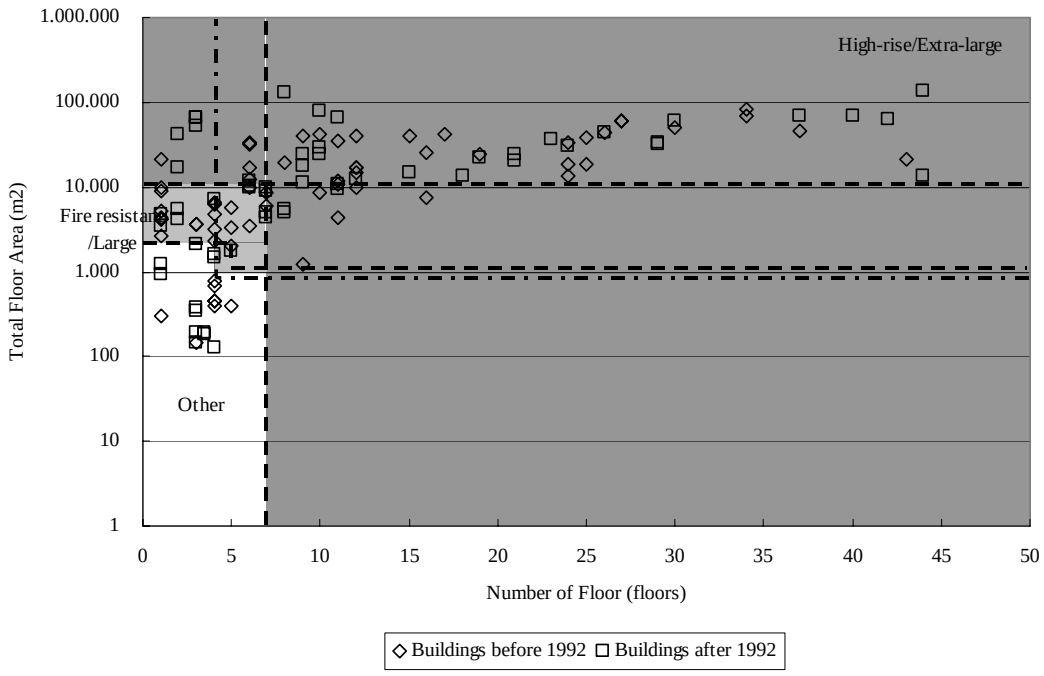
Source: JICA Study Team and NFPA journal

8.3 FIRE PREVENTION SYSTEM OF EXISTING BUILDINGS

8.3.1 Interview Survey on the Existing Buildings

An interview survey was conducted on the fire prevention systems of 125 existing buildings located in the Bangkok Metropolitan Area in the course of the Study. The survey covered 10 classifications of building which covers the target buildings of the Study. It carried out 6 to 19 buildings per classification. The surveyed buildings have the scale of approximately 21,000m^2 in average total floor area and an average number of 12 floors. Among the 125 buildings, 82 buildings or 66% are classified into high-rise and extra-large buildings as defined by MR 33.

Figure 8.3: Profile of the Surveyed Existing Buildings



Class.	Fireproof Build.	Large	Fireproof Build./ Large	Extra Large	High-rise	High-rise/Extra Large	Other	Total
Hotel	0	2	2	0	3	10	0	17
Office	0	0	0	0	2	17	0	19
Theater	0	8	1	2	0	2	3	16
Hospital	1	0	1	1	1	9	0	13
School	2	0	6	1	4	3	0	16
Factory	0	3	0	3	0	0	0	6
Multi-story housing	0	0	0	0	3	9	0	12
Shophouse	0	0	0	0	0	0	14	14
Dept. store	0	0	0	5	1	0	0	6
Complex	0	0	0	3	0	3	0	6
Total	3	13	10	15	14	53	17	125

Note: Definition of buildings by the MRs - 1)Fireproof building: 4 stories and 1000m^2 or more, 2) Large building: 2000m^2 or more, or 15m and 1000 - 2000m^2, 3) Extra large building: 10,000m^2 or more, 4) High-rise building: 23m or higher (for convenience, assumed 7 stories or more)

Eighty-one investigation items were set for the interview survey. Among them, 40 items were examined to tentatively identify the current situation of the fire prevention systems. The examined items are identified by a straight choice between two alternatives and consisted of five items for the management side and 35 items for the physical fire protection systems.

Table 8.14: Investigation Items by the Straight Choice between Two Alternatives

Stage of Prevention	No.	Fire Prevention Systems	Stage of Prevention	No.	Fire Prevention Systems
Prevention of Initial Fire Develop.	101	Fire Detector	Evacuation	306	Opening direction of door to evacuation route
	102	Gas Leakage Detector		307	Balcony appropriate for evacuation
	103	Alarming System		308	Evacuation route to main gate outside building
	104	Communication System		309	No obstacles on the fire exit routes
	105	All Detection/Alarming System		310	Vacant space on roof
	106	Portable Fire Extinguisher		311	Smoke control system
	107	Automatic Fire Extinguisher	Fire Fighting	401	Access for fire fighting vehicle
	108	Incombustible Interior Material		402	Fire access for fire fighting team
Prevention of Fire Spread	201	Partition by Floor Area		403	Firemen life lobby
	202	Partition at Stairway		404	Elevators
	203	Partition at Elevator		405	Firemen elevators
	204	Partition at Duct/Pipe		406	Indoor hydrant
	205	All Partition		407	Outdoor hydrant
	206	Fire prevention on outer wall		408	Fire hose cabinet
	207	Fire retaining door		409	Fire department connection
Evacuation	301	More than 1 evacuation direction	Management	501	Fire drill
	302	More than 1 fire stairs		502	Periodical inspection
	303	Exit signs on fire exit routes		503	Coordinator in case of fire
	304	Emergency lighting on fire exit routes		504	Fire manual and indication
	305	Fire retaining door to all fire stairs		505	Admission of fire insurance

Legend: Shaded items are installed by a half of surveyed buildings or more.

From the survey, the fire prevention systems installed by more than half of the surveyed buildings are listed below.

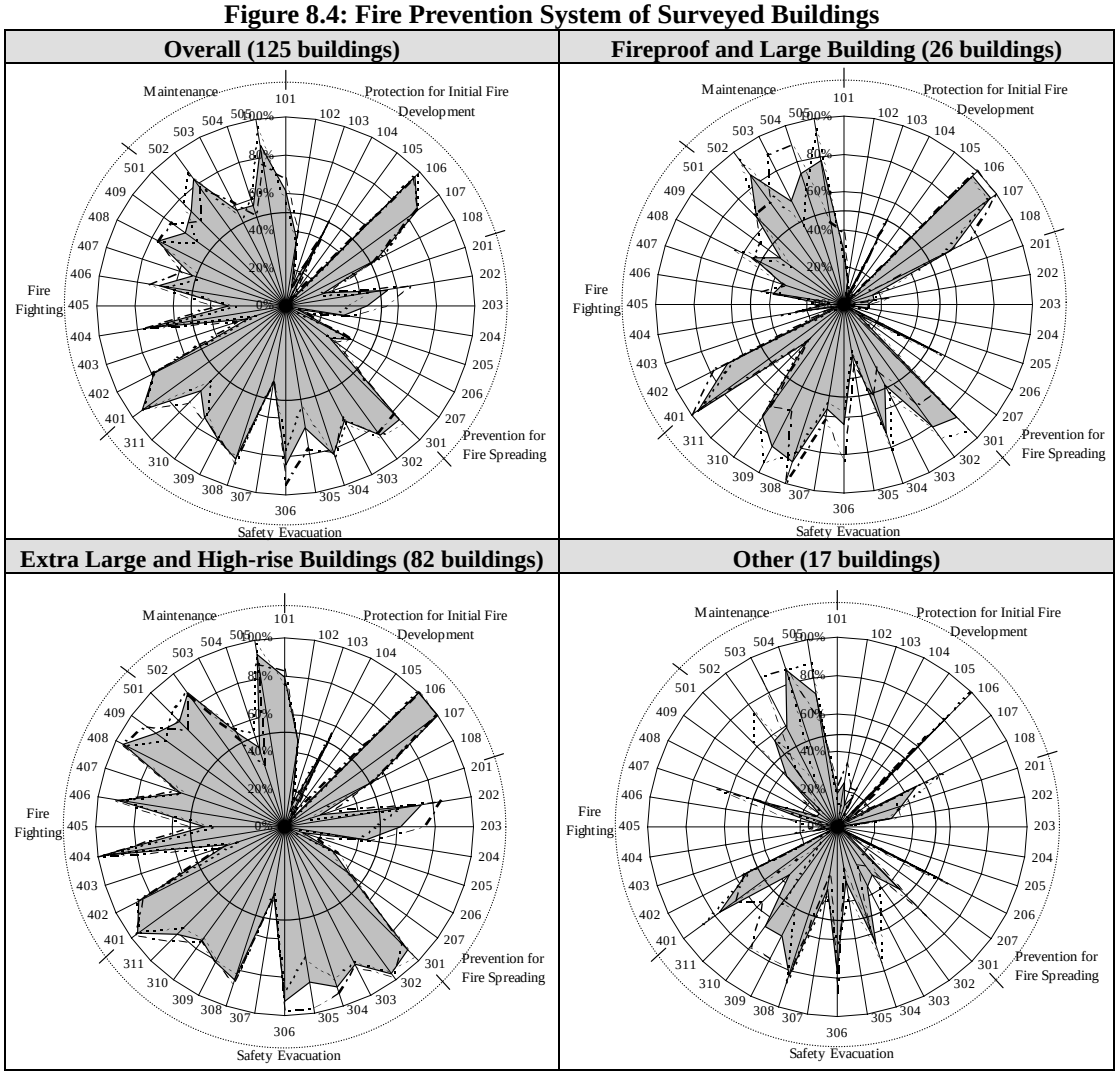
- Prevention of initial fire development: portable fire extinguishers and automatic sprinkler systems,
- Prevention of fire spread: vertical opening protection of staircases,
- Evacuation: multiple evacuation routes, exit signs, emergency lighting, fire doors of escape stairways, evacuation routes in a site, rooftop safety area, and smoke control system,
- Support for fire fighting: access for fire fighters, indoor fire hydrants, outdoor fire hydrants, and hose cabinets, and
- Management: all items: fire drills, periodical inspection, coordinator in case of fire, fire manual and indication, admission of fire insurance.

Although a reply from buildings where more than a half use of noncombustible interior material was obtained, it has been treated as outside of the evaluation, due to an insufficient definition of what can be classes of interior material.

Reflecting the requirements of the MRs, the surveyed buildings are provided with evacuation facilities and the support systems for fire fighting. This tendency is strongly apparent in the extra large buildings and the high-rise buildings, while the small-scale buildings focus on evacuation facilities. Apart from the requirements of the MRs, the surveyed buildings positively introduce evacuation management systems and evacuation routes in a site. The fire prevention systems of the surveyed buildings is shown in the following radar charts by classification of building.

Although the fire prevention systems are provided to comply with the MRs, some of lessons harnessed from the two major fires were not apparent in the surveyed buildings. More than a half of these buildings had no fire separation by floor area and vertical opening protection of the elevator shafts and pipe shafts. Due to the insufficiency of the MRs, the buildings having all four kinds of fire separation was limited to 7% of the total surveyed.

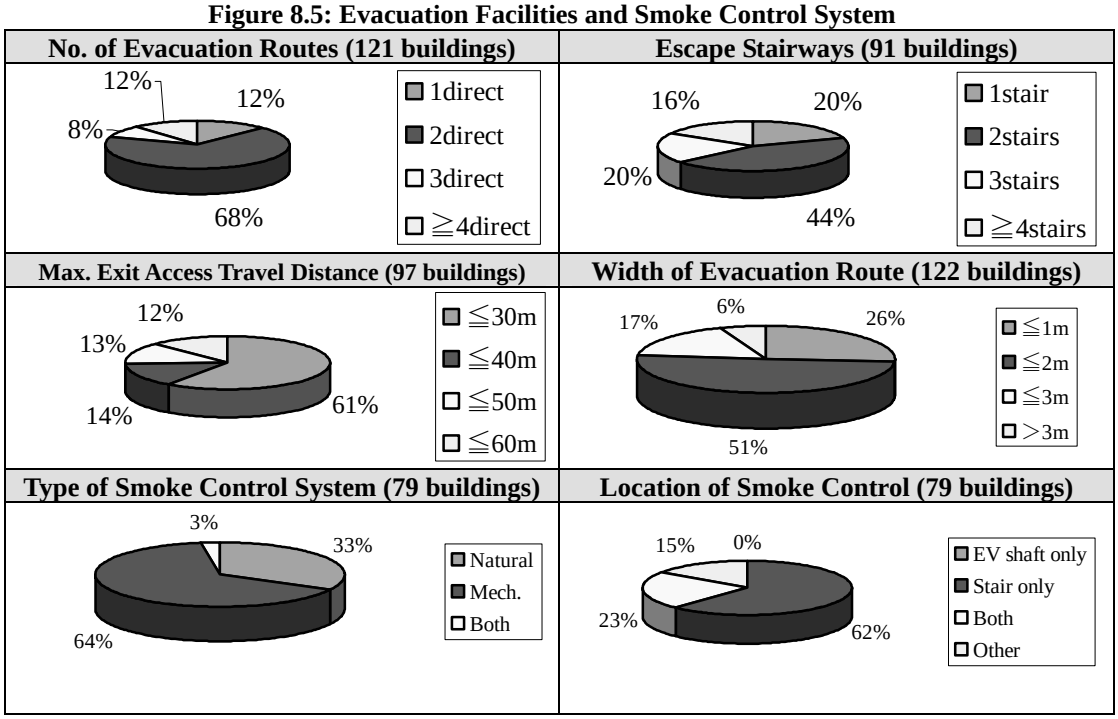
Figure 8.4: Fire Prevention System of Surveyed Buildings



Source: JICA Study Team

Other than the interview items discussed above, the remaining replies show more details of the existing fire prevention systems. Although 80% of the surveyed buildings had two evacuation routes, 20% had three evacuation routes or more, and 60% of the buildings allocate escape stairs within 60 m of the exit access travel distance. The most common practice for the width of evacuation route is from 1 m to 2 m, with half of the buildings adopting these widths. Mechanical exhaust is the most popular type of smoke control system, but it is installed only in staircases.

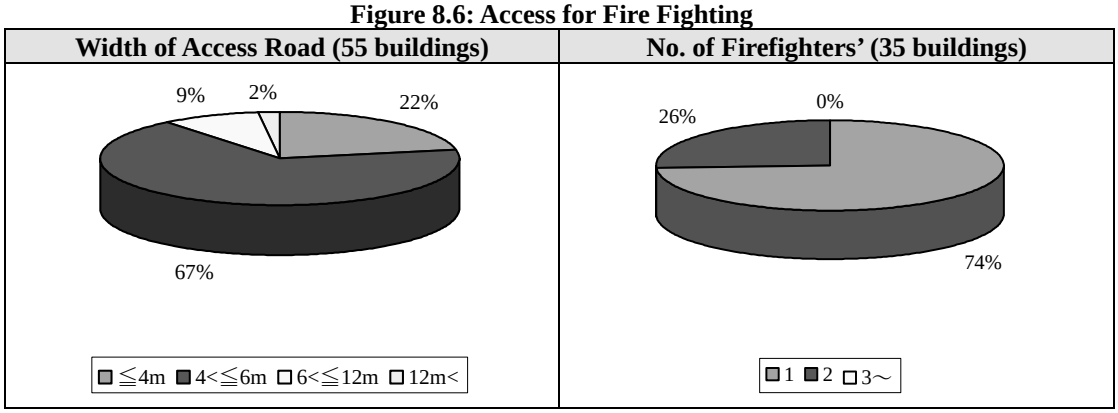
Figure 8.5: Evacuation Facilities and Smoke Control System



Source: JICA Study Team

About 70% of the buildings had external access at least 6 m in width. Among the buildings with elevators for firefighters, 25% are provided with two sets of firefighters' elevators.

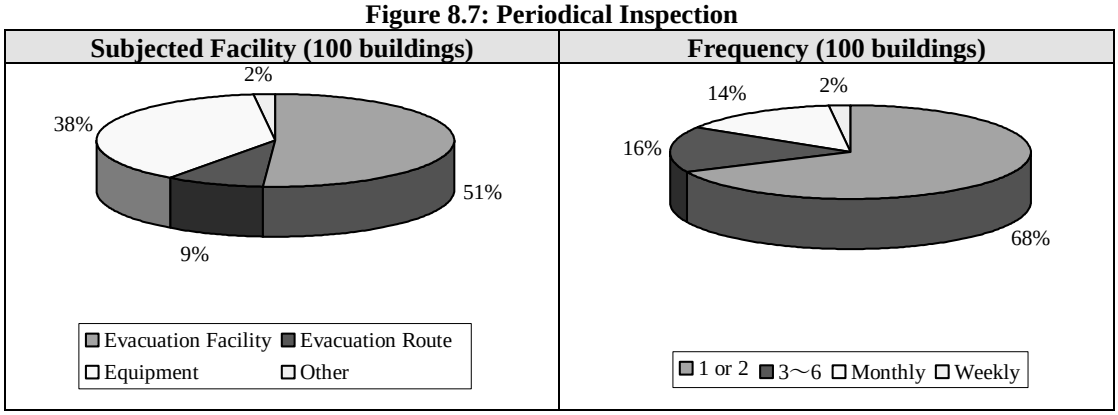
Figure 8.6: Access for Fire Fighting



Source: JICA Study Team

Buildings that currently carry out periodical inspections once a year account for about 70 percent of those surveyed. The subjected facilities for the inspection are mostly evacuation facilities (51%).

Figure 8.7: Periodical Inspection



Source: JICA Study Team

8.3.2 On-site Survey of the Existing Buildings

The Study has explored the fire prevention systems through a on-site survey for buildings in the BMA and the major local cities: Pataya, Hat Yai, Pukhet, and Chen Mai. Since the on-site survey was carried out on some ten buildings, this small number does not properly evaluate the fire prevention systems in Thailand. However the survey confirmed the current situation more than the interview survey did. It found that there are buildings provided with fire prevention system of a standard higher than that required by the MRs, however some systems can not perform the expected function. This is due to unsuitable design and management, since the MRs do not comprehensively specify the technical standard of how to install the fire protection systems. For example, the following were observed;

- Gas pipe of a cooking room on a floor surface,
- Heat detectors installed in front of an outlet of an air conditioning,
- Sprinkler heads above a generator,
- Opening more than 10cm between a fire door and a floor surface,
- Water supply pipes used for handrails of an escape staircase,
- Sudden change of an escape staircase to a ladder,
- Openings of an escape staircase with pressurized smoke control system,
- No uniformity of exit signs made with wood,
- No uniformity of type and pitch of an escape staircase, and
- Large cooking room directly connected to an escape staircase.

The survey also confirmed usage of noncombustible material for interior finish. Some of the buildings have vertical opening protection at pipe shafts. On the maintenance side, the survey clarified improper uses such as the malfunction of a

receiver for detectors, combustible materials stored in an escape staircase in large quantities, and locked fire hoses. These insufficient design and maintenance items do not reflect the lessons learnt from the major fires.

Table 8.15: Improper Design and Maintenance of the Fire Prevention System

Stage of Prevention	Problematical Issue found through the On-site Survey	
	Design	**Maintenance**
Prevention of Outbreak of Fire	• Gas pipes on floor of a kitchen.	
Prevention of Initial Fire Development	• Detectors in front of an outlet of an air-conditioner. • Sprinkler heads above a generator. • Combustible materials for interior finish.	• Malfunction of a receiver for detectors.
Prevention of Fire Spread	• Gap more than 10cm between a fire door and a floor surface. • No fire separation of pipe shafts. • Wooden door of pipe shafts. • Openings between a kitchen and a pipe shaft without any fire protection equipment. • No fire separation of an atrium.	
Evacuation	• Opening at the top of an escape staircase provided with pressurized smoke control system. • Non-continuous escape staircases. • Wooden exit sign. • No uniformity of illustration for exit signs. • Dust chute in an escape staircase. • Water supply pipe for fire fighting used as handrails in an escape staircase. • No uniformity of width and type of stairways. • Large kitchen directly faced with an escape staircase.	• Stored combustible materials on evacuation routes. • No testing of pressurized smoke control system to inspect air pressure.
Support for Fire Fighting		• Locked fire hoses.

Source: JICA Study Team

8.3.3 Consideration on the Fire Prevention System of Existing Buildings

Although fire prevention systems have been developed by legislation of the Ministerial Regulations (MRs), their design and condition are not appropriately maintained, mainly since the MRs do not cover technical standard in enough detail.

Existing buildings still have the same defects in fire prevention systems that assisted the spread and large damaged area of the two major fires in the past. The amendments on the MRs are necessary to additionally regulate the fire separation, the noncombustible interior finish, and the technical standards that will ensure the appropriate design.

On the other hand, the surveys confirmed the existence of buildings introducing by their own efforts, fire prevention systems and management systems of standards higher than that required by the the MRs, as listed below.

- Fire fighting control room,
- Self-defense fire fighters who served as security guard, and
- 24-hours emergency power supply units of hotels and shopping centers.

PART III RECOMMENDATIONS ON FIRE CODES AND TECHNICAL STANDARDS

CHAPTER NINE:
POINTS OF VIEW FOR RECOMMENDATION

9.1 PURPOSES OF RECOMMENDATION

This part focuses on the fire safety standard that all buildings should achieve in a physical fire protection system, among various factors in fire prevention. From the review of the Building Control Act and the technical standards of Thailand that are used during the process of building construction, recommendations are made to enhance the fire safety of future buildings that will be constructed in Thailand.

Moreover, the recommendation covers points for the amendment of the fire codes through the examination of the fire safety of existing buildings that have high risk of fire. The recommendation also aims to strengthen the fire safety of existing buildings.

9.2 SIGNIFICANCE OF RECOMMENDATION

To apply effective measures for building safety, each fire protection technology should be systematically implemented based on the requirements of the fire codes. It is crucial to set specific values in the fire codes to make the fire protection systems effective.

However, specific values cannot be set on a scientific basis. Simulation and testing methods for specific areas of fire protection have been developed, but no scientific and objective evaluation methods are developed to verify the fire safety of a whole building at present. In general, fire codes in other countries have been formulated from lessons learnt from fires in the past, and are only suitable for application depending on the social characteristics of the country concerned, such as economic level and national public consciousness of fires.

Therefore, the recommendation does not include requirements with numeral criteria, but points out crucial issues for the amendment of the fire codes. The numeric criteria should be determined through due process that takes into consideration the socio-economic conditions in Thailand and national consensus.

The numeric criteria for each fire protection technology in the fire codes of developed countries such as Japan and the USA are presented in Chapter 10 of this report. The presented values may be useful to refer to when the numeric criteria are being examined for the amendment of the fire codes in Thailand in the future.

9.3 POINTS OF VIEW FOR RECOMMENDATION

Recommendation for amendment of ministerial regulations reflects proposed programs in Part I of this report and the following eight topics.

(1) Life Safety and Strengthening of Passive System

It is indispensable for life safety against building fires to secure adequate evacuation routes. On the other hand, fire protection system of buildings are classified into two types: Active system with external supports by electricity or hydro-power for its operation and Passive system without any external support. Taking into consideration the causes of past large fires and current situation of fire protection systems of existing buildings in Thailand, it is desirable that fire safety of buildings is secured by the passive system.

In the recommendations, the amendment of ministerial regulations focuses on securing life safety and developing reliable fire protection systems. It aims to strengthen adequate evacuation routes, provision of fire separation and smoke separation, use of noncombustible interior finish. In addition, strengthening of active systems, such as sprinklers and fire hydrants, should be examined with local characteristics of preparation level for fire fighting and infrastructure.

(2) Composition of Recommendation

Since the history of large building fires is rather short in Thailand, many basic technologies and skills for fire protection are missing in the fire codes. Therefore, recommendations that only point out the necessary amendments to the articles of the existing ministerial regulations would not comprehensively cover all necessary fire protection technologies.

The recommendations therefore adopt comparisons with the fire protection systems commonly specified in the fire codes of other countries to identify necessary fire protection technology that is not present in the fire codes in Thailand. In addition, the recommendation also clarifies the necessary improvement of the technology that is already articulated in the fire codes in Thailand.

Common practices for building fire protection in developed countries consist of the following six items.

(i) Prevention of Outbreak of Fire,

(ii) Prevention of Initial Fire Development,

(iii) Prevention of Fire Spread,

(iv) Evacuation,

(v) Fire Fighting, and

(vi) Prevention of Building Collapse.

(3) Special Concern for Buildings owned by Private Persons

As mentioned in the previous section, there is no universal evaluation method for building fire safety. Therefore, strengthening of requirements for buildings owned by private persons, such as residences should be initiated by national consensus. The strengthening for these buildings needs technical analyses on past typical fires which may present necessity of the amendment with scientific backgrounds.

It is desirable that amendments progress on improvement for private-owned buildings which have large floor areas and large number of occupants. These buildings are considered as kinds of public buildings which have high hazards for lives in case of fires. For example, it is recommendable to specify detection/alarming systems, evacuation tools, and evacuation routes for shop-houses larger than the certain scale. Target buildings also may include ones with ignitable and/or combustible materials, such as gasses, more than specified amounts.

On the other hand, buildings of the private sector should form adequate fire protection systems, in case where the buildings are used by public and highly hazardous for lives when a fire breaks out.

(4) Definition of Complex Buildings

In the disaster prevention planning, It is fundamental that complex buildings are divided into parts of each building use to secure proper implementation and management of evacuation and fire fighting. Part of each building use is enclosed by fire separation, and the evacuation routes are independent by building use from one to another. In addition, supporting systems for fire fighting, such as fire fighting command centers are provided corresponding to individual building use.

Recommendations focus on requirements of fire protection system for individual building uses in conditions where complex buildings are subdivided as mentioned above.

(5) Alleviation and Trade-off

Recommendations introduce fire protection systems which have never been specified in ministerial regulations, such as fire separation, smoke separation, and use of noncombustible interior finish. The amendment of MRs should take into consideration trade-off of fire protection systems, in case where purposes and functions of newly introduced protection systems overlap with those of existing protection systems. Alleviation methods are also necessary to mitigate excessive requirements causes by new fire protection systems. Both mitigation methods are effective for giving the flexibility to the planning of building disaster prevention.

It should be noted that alleviation and trade-off by introduction of active systems should be examined with preparatory level of operation and maintenance. The recommendations include samples of alleviated requirements in different countries that aim to be useful for the examination of amendments in the future.

(6) Specification Based Codes and Performance Based Codes

Enforcement of performance based codes require scientific evaluation methods for the fire protection systems proposed to meet with specified performances. To achieve this, provision of essential information, testing technologies, and verification methods are necessary. However essential technologies are still at the initial stage of developments in Thailand. It is recommended that the performance based codes are introduced in the future in accordance with improvements of technologies. In reality, amendments firstly focus on expansion of specification based codes, and then performance codes are phased-widely provided with reflecting of technologies that are obtained through the development of specification based codes. The recommendations focus on the specification based codes necessary for the first step of amendments in Thailand.

(7) Provision of Test Standards

It is crucial for enforcement of the building control act that evaluation methods by testing for elements of fire protection are specified in the fire codes. It is recommended that test standards conform to the ISO standards as mentioned in the Part I of this report.

Recommendations include outlines of test methods and evaluation criteria for noncombustible materials of interior finish and the fire-resistance rating of building elements in different countries.

(8) Treatment of Special Buildings, Assembled Parts, and Materials

Every building has unique characteristics in view points of fires. It is desirable that fire codes specify measures to evaluate the fire safety of special buildings, assembled parts, and materials which are not assumed by the codes. The special buildings may be ones considerably larger than target buildings of MR 33. However the provision of evaluation system inevitably needs developments of experts and preparation of essential technologies as its prerequisites. As mentioned in section (6), in Thailand basic technologies for fire protection are developed from now on.

Therefore recommendations focus on essential requirements to be specified in fire codes, while the evaluation method and its assessment procedures for special buildings, elements, and materials needs to be developed in the future when fire protection technologies are well-developed together with sophisticated experts.

9.4 PREREQUISITE FOR RECOMMENDATION

It is a premise for the drawing up of the recommendation on the amendments of fire codes that all the main projects and programs recommended in Part I of this report are implemented.

The following two points are especially important:

i) That the fire code in Thailand consists of the Building Control Act, ASA standard, and EIT standard.

ii) That a testing, evaluating, and accrediting system for building materials and construction is established.

CHAPTER TEN:
MAIN POINTS OF RECOMMENDATION ON TECHNICAL REQUIREMENTS

10.1 PREVENTION OF OUTBREAK OF FIRE

Although the prevention of outbreak of fire relies on conditions of building use and maintenance, it also requires a physical fire protection system to secure the fire safety performance of a building. The Ministerial Regulation under the Fire Prevention and Fire Fighting Act controls hazardous materials for fire prevention. It also specifies the ventilation, fire separation, and isolation from heat resource for the hazardous material. On the other hand, the Building Control Act does not specify any requirements for the hazardous material and its fire protection measures. Since adopting measures for outbreak prevention is the first step to achieve fire prevention of buildings and has the effect to largely reduce the risk of fire, it should be recognized as an important measure in the fire codes of the Building Control Act.

The important items of physical fire protection of a building for the prevention of outbreak follow.

i) Safety in a Room having Fire Equipment

It is desirous that fire codes specifies safety measures for a room having fire equipment, such as kitchens. Requirements of the safety measures should include the locations of air outlets of air conditioners and heat sources are specified in the fire codes. In addition, installation of gas leakage detectors, smoke exhaust equipment, and automatic stoppers at gas cooking stoves are specified in fire codes.

ii) Definition and Separation of Hazardous Materials

Hazardous material should be separated from a heat source. Since the hazardous materials have various types depending on the classification of building, it is not appropriate that every kind of these materials is specified in the Building Control Act. Preferably hazardous materials are stipulated by the Act and related codes, such as the Fire Prevention and Fire Fighting Act with good co-ordination to comprehensively cover the materials.

In the Building Standard Law (BSL) of Japan, criteria for the quantity of each ignitable material are specified to determine whether fireproof or quasi-fireproof construction is necessary. The BSL also specifies fire protection technology by ignitable material that exceeds the designated quantity by the Fire Service Law.

iii) Noncombustibility of Main Habitable Rooms

Use of noncombustible materials for the interior finish is preferable for specific parts of a building, such as the seating area of a restaurant, the guestrooms of hotels, and

the meeting rooms where the possibility of outbreak is high and fire may cause severe conditions. Noncombustible materials are also preferable for built-in furniture such as lockers, closets, and book shelves.

iv) Attention in Planning of a Building

The floor layout of a building has to reduce any blind point to prevent any incendiary effect and to enable the early detection of fire outbreak.

10.2 PREVENTION OF INITIAL FIRE DEVELOPMENT

10.2.1 Detection and Report/Alarm

Both MR 33 and MR 39 stipulate installation of fire alarm systems. However, these MRs define the fire alarm system as a combined system of "detection" with "report/alarm", both of which have different characteristics from each other. Clarification to separate these two items is necessary to confirm the purpose of each individual system. The following should be taken into consideration.

i) Strengthening of Provision for Detectors Installation

The MRs have no clear requirement for the installation of detectors, which are indispensable for the discovery of an outbreak of fire. Amendments are required to specify target types of buildings based upon the clear definition of the detectors. In the course of determination of the target buildings, it is effective to focus on rooms used for sleeping as specified in the IBC of USA, while designation by scale of the target building is one method that can be used to specify the necessity for detectors. In buildings such as hotels and hospitals, where early detection of fire is important, it should be required to install detectors regardless of how small the scale of the building is.

There are three main types of detectors, smoke detectors, heat detectors, and flame detectors. From the experience of fire at the hotel, it is recommendable to include a gas leakage detector in the MRs. For each type of detector to fully function, technical standards should specify the procedure for proper installation and the selection of detector type that properly corresponds to the form and goods of a room.

Table 10.1: Requirements for Detectors

Type	Classification	MR	BSL&FSL	IBC&IFC
Heat, Smoke, and Fire Detector	General	1) Building with: • 10,000m^2 or more in total floor area • 23m or higher • 2000m^2 and 4 stories or mor 2) Every housing unit	1) Building of 1,000m^{2}or more in total floor area 2) 300m^2 or more in underground floor, floor without window, and 3rd floor or higher 3) Building with 11 stories or higher	1) Building higher than 22.86 m from the height of a ladder truck 2) Atrium (with smoke detector)
	Hotel	Building with 2000m^2 or more in total floor area	Modify 1) of the general to300m^2 or more.	1) Part for sleeping 2) Room along evacuation routes 3) Floor having guestrooms 4) Underground floor
	Office		Refer to the general.	Refer to the general.
	Theater		Modify 1) of the general to300m^2 or more.	Refer to the general.
	Hospital		Modify 1) of the general to300m^2 or more.	1) Part for sleeping 2) Floor having sickroom 3) Underground floor (Excluding a part of 2) and 3) with sprinkler system.)
	School		Modify 1) of the general to500m^2 or more.	Refer to the general.
	Factory		Modify 1) of the general to500m^2 or more.	Refer to the general.
	Multi-story housing		Modify 1) of the general to500m^2 or more.	1) Part for sleeping 2) Floor having housing unit 3) Underground floor
	Dept. store		Modify 1) of the general to300m^2 or more.	Refer to the general.
	Selection of Types of Detectors	No specification	1) Smoke type: staircase, slope, shaft, linen chute, pipe duct 2) Smoke or a combined smoke and heat type: corridors and aisles 3) Smoke or fire types: ceiling height within 15-20m 4) Fire type: ceiling height of 20m or more 5) Smoke, fire, or a combined smoke and fire type: a) a part other than the above-mentioned, and b) underground floor, floor without window, and 11th floor or higher	1) Smoke detector is recommended for automatic detectors (connection with automatic fire alarm and emergency public address system) 2) Smoke detector for atriums
	Alleviation/Trade-off	No specification	Trade-off by sprinkler systems, water spray system, and form sprinkler system.	Trade-off of heat detectors by a combined system of sprinkler system and connection with alarm systems.
	Emergency power supply	2-hours supply	10-minutes supply	Required
	Notes	No clear definition of detector.	Clearly specifying detectors combined into automatic fire alarm system.	1) Separately specifying detectors and alarm systems 2) Subdividing an area into zones within 2,090m^2 and 91,44m on a side of a zone
Gas Leakage Detector	Hotel, theater, hospital, Dept. store	No specification	Underground floors of 1000m^2 or more in total floor area	Required at a part having toxic gasses
	Office, school, factory, multi-story housing		No specification	
	Note		Specifying connection with alarm system.	

Source: JICA Study Team

Table 10.2: Selection of Detectors (The Fire Service Law in Japan)

Installed Point		Type of Detector		
	Example	**Heat**	**Fire**	**Smoke**
Dusty	Lumbering factory, painting factory	OK	OK	
Vapors	Boiler room	(OK)		
Corrosive gasses	Battery room	(OK)		
Smoke in daily use	Kitchen	(OK)		
Very high temperature	Dry room, boiler room	(OK)		
Exhausted gasses	Parking, generation room	(OK)	OK	
Inflow of smoke	Service room, room next to kitchen	OK		
Condensation	Warehouse	(OK)		
Exposed flame	Glass factory, kitchen	(OK)		
Insufficient ventilation and storing smoke by cigarette	Conference room, restaurant, meting room	(OK)		(OK)
Sleeping facility	Guestroom, napping room			OK
Minute particles except smoke	Corridor, aisle		OK	OK
Windy	Lobby	(OK)	OK	(OK)
Long distance from origin of smoke	Staircase, elevator shaft			(OK)
Inflammable combustion	Computer room, machine control room			(OK)
Diffused heat and smoke in a room with high ceiling and large area	Gymnasium, factory, warehouse		OK	(OK)

Source: JICA Study Team
Note: OK: Appropriate for the installed point,
(OK): one or more types are appropriate or special treatment is necessary to install.

ii) Proper Use of Report and Alarm System

It is crucial to provide occupants with proper information on a fire, at each stage, from detection of a fire to the completion of evacuation. In the fires in the hotel and doll factory, the malfunction of the fire alarm system resulted in delays in the initial actions by building managers, the evacuation, and the enlargement of losses. As stipulated in the current MRs, it is meaningful to require the installation of reporting and alarm systems in high-rise buildings, large scale buildings, and complex use buildings, where occupants will take a long time to complete evacuation and easily fall into panic. Similarly to the detectors, the requirements of the MRs should include rooms used for sleeping to cover small-scale buildings. Both fire codes in Japan and the USA widely require the report and alarm systems in all the building use and small-scale buildings by specifying a mobile alarming tool.

On the other hand, the measure of simply installing a fire alarm may trigger panic of occupants in these buildings. Therefore the MRs have to specify the installation of an emergency public address system and the co-ordination with a fire fighting control room that will allow the zoning of alarming systems and prevent any false or mischievous alarms or messages.

Table 10.3: Requirements for Alarming System

Classification	MR	BSL&FSL			IBC&IFC
		Fire Alarm, Automatic Siren, or Public Address System	**Fire Alarm + Public Address System, or Automatic Siren + Public Address System**	**Mobile Emergency Alarm Tool**	
General	1) Building having: • 23m or higher • 10,000m^{2}or more in total floor area 2) Every housing unit	Building with: 1) 50 occupants or more 2) 20 occupants or more in underground floor and floor without window	Building with: 1) 11th floor or higher 2) Basement 3rd floor or lower	20-49occupants	Building being 22.86m or higher from the access for firefighters. (Installment of emergency alarm equipment and public address system)
Hotel	No specification by the classification of building	Building with 20 occupants or more	Building with 300 occupants or more	Refer to the general	Every building (Manual fire alarm and automatic detector are adopted.) (Excluding the fire alarm at a part separated by fire separation and located at 2nd floor or lower. The part also has to have an direct access to a public road.) (Excluding the automatic detector at a guestroom having direct access to the outside.)
Office		Refer to the general	Refer to the general	Refer to the general	1) 500 occupants or more 2) 100 occupants in a floor located one floor higher or lower than the lowest safety floor (Manual type is adopted.) (Trade -off by automatic sprinkler system)
Theater		Refer to the general	Building with 300 occupants or more	Refer to the general	300 occupants or more (Manual type is adopted. Public address and fire alarm is required for 1,000 occupants or more.) (Trade -off by automatic sprinkler system)
Hospital		Building with 20 occupants or more	Building with 300 occupants or more	Refer to the general	Every building (Manual fire alarm and automatic detector are adopted.) (Excluding a hospital room easily observed from a nurse room.)
School		Refer to the general	Building with 800 occupants or more	Refer to the general	50 occupants or more (Manual type is adopted.) (Trade -off by various fire protection systems)
Factory		Refer to the general	Refer to the general	Refer to the general	500 occupants in 2nd floor or higher and a floor located one floor higher or lower than the lowest safety floor (Manual type is adopted.) (Trade -off by automatic sprinkler system)
Multi-story housing		Refer to the general	Building with 800 occupants or more	Refer to the general	1) Housing unit at a floor higher by three floors from the lowest safety floor. 2) Housing unit at a floor higher or lower by two floors from the lowest safety floor. 3) 16 housing units or more (Fire alarm is mandatory.) (Excluding the fire alarm when the housing units in the 2nd floor or lower are divided by 1-hour fire separation. The housing unit has a direct access to the outside.)
Dept. store		Refer to the general	300 occupants or more	Refer to the general	1) 500 occupants or more 2) 100 occupants or more (one floor upper or higher than the lowest safety floor.) (Manual type is adopted.) (Trade -off by automatic sprinkler system)
Note	-	Trade-off of fire alarm tool, fire alarm, automatic siren, and public address system by automatic fire alarm system.			-

Source: JICA Study Team

10.2.2 Initial Fire Extinguishing

The initial fire extinguishing is formed by the installation of portable fire extinguishers, sprinkler systems, and indoor fire hydrants. In this section, the recommendation focuses on the sprinkler system having important role of the initial fire extinguishing. The indoor fire hydrant is discussed in another section.

Although the sprinkler system has high efficiency for initial fire extinguishing, any careless maintenance may reduce the effectiveness. Therefore measures for strengthening the maintenance system need to be examined in the course of legalization to strengthen the installation of the sprinkler system.

In addition, roles of sprinkler systems include fire extinguishing in the stage of fire fighting. MR 33 specifies the capacity of water resources for fire extinguishing in buildings. The capacity is stipulated to be capable for 30 minutes supply which is considered as use for initial fire extinguishing. Therefore, sprinkler systems for fire fighting require connections with fire department hydrants, pump trucks, and urban water supply systems. It should be noted that strengthening or introduction of sprinkler systems is provided in the regions where public fire fighting facilities and urban water supply systems are adequately prepared.

In Japan, the sprinkler systems have been introduced step-by-step as noncombustible interior finish was required earlier than sprinkler systems because the performance of sprinklers had not been considered trustworthy. On the contrary to Japan, in the USA, the sprinkler system widely prevails due to the preferential treatment of insurance rates for buildings installed with sprinklers.

i) Expansion of Target Buildings

In Thailand, MR 33 specifies the installation of sprinklers at every floor of a building with a height of 23 m or more or with total floor area of 10,000 m^2. It focuses on considerably large-scale buildings. It is recommendable to extend the specifications for target buildings so as to include buildings smaller than those included in MR 33 and also to large habitable rooms and other rooms that are important for fire prevention. This strengthening of the target buildings is typically needed for hotels, theaters, hospitals, schools, multi-story housing, and department stores.

Upon the expansion of target buildings, it is recommendable to enforce alleviation by the installation of sprinklers to prevent building owners from excessive construction cost. The alleviation should be coordinated with fire separation as mentioned later, as fire codes in Japan and the USA specify some kinds alleviation by the installation of other fire protection systems.

ii) Improvement of Technical Standards for Ensuring the Workability of Sprinklers

The MRs abstractly specify the necessity of the sprinkler system without any technical standard for the installation. The EIT standard substantially complements the technical standards that specify the type of sprinkler and fire extinguishing agent, the interval of sprinkler heads, the sprayed water volume, the water pressure, and the duration of operation.

The EIT standard specifies basic requirements of types of sprinkler and fire extinguishing agent, the interval of sprinkler heads, the sprayed water volume, the water pressure, and the definition of any excluded part from the sprinkler system. It covers the technical standards by introducing the types of sprinkler heads (open-head type, close-head type, and gun-head type), the fire extinguishing agent (foam, carbon dioxide, and dry chemical) with provisions of the prerequisite of a room. In addition, it also specifies the water volume of water supply pipes and the sprayed water volume by unit floor area.

A basic condition for determination of the operation time is to assume the time for arrival of the firefighters. Since there is large distinction in the enrichment of road network and fire fighting equipment among the regions in Thailand, it is preferable to differently specify the installation criteria of sprinklers in each region by reflecting the characteristics of urbanization in that region.

Table 10.4: Requirements of Automatic Sprinkler System

Classification	MR	EIT	BSL&FSL	IBC&IFC
General	1) Every floor of a building with 10,000m^2 or more in total floor area 2) Every floor of a building with a height of 23m or higher	-	Building having 11th floor or higher	1) A floor having 139.4m^2 or more and without window 2) 30 occupants in a floor higher by 16.8m from the access of a fire engine (except factory) 3) Duct: a) At the end and start of dust chute and linen chute b) Ducts to transfer combustible materials c) Exhaust system and duct at a kitchen for commercial
Hotel	Refer to the general	No specification to regulate a building required with sprinkler system	1) 2nd floor or higher: 3,000m^{2}or more in total floor area 2) 4-10th floor:1,500m^2 or more in floor area 3) Underground floor and floor without window: 1,000m^2 or more in floor area	Every building
Office			Refer to the general	Refer to the general
Theater			1) 2-stories building or higher: 6,000m^{2}or more in total floor area 2) 4-10 stories building: a floor with 1,500m^2 or more 3) Stage with 500m^2 or more (300m^2 for underground floor, floor without window, and 4th floor or higher.)	1) A part more than 1,115m^2 2) A part with 300 occupants or more 3) A floor except a safety floor
Hospital			1) 2-stories building or higher: 3,000m^2 or more 2) 4-10 stories building: a floor with 1,500m^{2}or more 3) Underground floor and floor without window: a floor with 1,000m^2 or more	Every building
School			Refer to the general	1) A part more than 1,858m^2 2) A floor lower than the safety floor
Factory			Refer to the general	Refer to the general (Excluding 3) of the general.)
Multi-story Housing			Refer to the general	1) 2-stories building or lower: more than 16 housing units 2) 3rd floor or higher (including basement floors)
Dept. Store			1) 2-stories building or higher: 3,000m^{2}or more in total floor area 2) 4-10 stories building: a floor with 1,000m^2 or more 3) Underground floor and floor without window: a floor with 1,000m^2 or more	1) A part more than 1,115m^2 2) A total floor area more than 2,230m^2 3) 4-stoiries building or higher

Source: JICA Study Team

Table 10.5: Technical Standard for Automatic Sprinkler System

Item	EIT	BSL&FSL	IBC&IFC
Interval of Heads	1) Light hazard: 4.6m 2) Moderate hazard: 4.6m 3) High hazard: 3.7m	1) General: 1.7 m or 2.1 m 2) Fireproof building: 2.3m	1) Light and moderate hazard: 4.6m 2) High hazard: 3.7m 3) Warehouse with highly stored things: 3.7m
Volume of Sprayed Water	1) Light hazard: 1895 - 2840l/minute 2) Moderate hazard: 3218 - 5680l/minute (in riser pipes)	50-80l/minute	(Water in riser pipe) 1) Light hazard: 1892.5 - 2838.8l/minute 2) Moderate hazard: 2649.5 - 3785l/minute(Group I) or 3217,3 - 5677.5l/minute(Group II) (Sprayed water) 1) Light hazard: 139-372m^2、4.1-2.0l/min/m^2 2) Moderate hazard: 6.5-3.3l/min/m^2 (Group 1), 7.7-4.9l/min/m^2 (Group 2), 8.5-6.1l/min/m^2 (Group 3)
Pressure of Sprayed Water	1) Light Hazard: 103.5KP 2) Moderate Hazard: 138KP	0.1MP	0.1MP
Volume of Water Resource	No specification	1) Closed type: a) 1.6m^3/normal head b) 1m^3/head for small compartment c) 1.6m^3/head for side wall type 2) Open type: 1.6m^3/head	No specification
Duration of Power Supply and Water Supply	Duration of water supply: 1) Light hazards: 30 - 60 minutes 2) Moderate hazards: 60 - 90 minutes 3) High hazards: 90 - 120 minutes	Duration of power supply: 30 minutes	Duration of water supply 1) Light hazard:30 - 60 minutes 2) Moderate hazard(Group 1 and 2):60 - 90 minutes 3) Moderate hazard (Group 3): 60 - 120 minutes
Excluded Parts	1) Electric room (2-hour fire separation) 2) Opened part, such as balconies 3) Noncombustible ceiling 4) Operating room	1) Staircase, bathroom, and toilet 2) Room for electricity, communication, machinery, and equipment 3) Elevator shaft, linen chute, and pipe shaft 4) Corridor opened to outside 5) Room for operating, maternity, and x-ray	1) Room with detectors 2) Room made with noncombustible materials 3) Room for electricity and communication (2-hours fire separation)
Type of System	Wet type for general uses, Dry type for cold districts, Differential motion type for important part, and Deluge type for hazardous		
Type of Agent			
Water Spray	Specified	Parking, electric equipment, boiler, and communication room	No specification
Foam		No specification	Same with sprinkler system
Carbon Dioxide		Electric equipment, boiler, drying, and communication room	Same with sprinkler system
Powder		Room having fire equipment	No specification
Wet Powder		No specification	Same with sprinkler system
Dry Powder		No specification	Same with sprinkler system
Volatilization		No specification	Same with sprinkler system

Source: JICA Study Team

10.2.3 Use of Noncombustible Materials for Interior Finish

Lack of physical fire spread protection is pointed out as one of the causes that expanded the damage of the fire at the Royal Jomtien Hotel. After the outbreak of the fire in a kitchen, the fire quickly spread fuelled by the combustible materials used for the interior finish in the kitchen, it's adjacent passageways, and halls. However the use of noncombustible materials is not specified for the prevention of initial fire in the MRs.

In Thailand, the fire protection by initial fire extinguishing has been introduced. However fire protection by a building structure (passive system) is preferable for a country where the operation and maintenance procedures of the fire protection systems (active system) is not well developed. In fact, malfunction of fire alarms and fire pumps occurred in the hotel fire. The way is suitable, given the current circumstances in Thailand, to introduce the active system as a supporting measure for the passive system. Therefore, it is strongly recommended to introduce the requirements to use noncombustible materials for interior finishes in the MRs. The following points should be addressed.

i) Definition of Noncombustible Materials and Setting of their Performance

The MR should specify the definition, purpose, and grade of the noncombustible materials for interior finish with the required fire resistance performance by each grade. It is recommended that interior finish is defined as an exposed surface of a building and it does not include furnishing, furniture, and goods stocked in the building, such as curtains. Criteria of fire resistance performance are desirable to include restrictions for five items: i) ignitability, ii) flame spread velocity , iii) combustibility, iv) generated volume of smoke, and v) volume of generated toxic gasses. The noncombustible materials should be classified into three or five grades. The classification of five grades for noncombustible materials are recommended as shown below.

- Noncombustible materials (i.e. cement boards, concrete blocks, etc.)
- Quasi-noncombustible materials (i.e. gypsum boards and cement boards, both of which are finished with light paintings on their surfaces, etc.) This type of materials slightly causes combustion.
- Fire retardant materials (i.e. plywood, wood fiber boards, and plastics with fire-proofing, etc.)
- Combustible materials (i.e. plywood and woods, etc.)
- Highly combustible materials (i.e. plastics and plastic insulation materials, etc.)

In addition, the MR should specifically designate testing, evaluation, and accreditation bodies. The details of these requirements are discussed in other sections.

ii) Designation of Target Buildings

Nominated scale buildings accommodating a fixed number of people are suitable to be target buildings, although all types of buildings are targeted in the current EIT standard. It is desirous that small scale buildings, whose owners are weak in their capital strength, and buildings where evacuation is easy, can be excluded from the target buildings.

iii) Designation of Target Building Parts

Target parts of buildings for introducing noncombustible materials are rooms where people tend to stay in case of fire, such as habitable rooms and evacuation routes that are important for safe evacuation. Noncombustion of walls and ceilings is essential, because fire develops along the wall and ceiling. High temperature gas deposits in the upper layers of the room, and fire develops along that layer. On the contrary, the current EIT standard has further included floors for using noncombustible materials. Therefore, the target in the EIT standard should focus on walls and ceilings, to meet the known development habits of a fire.

iv) Introduction of Alleviation Stipulation

Alleviation of noncombustible interior finishing and exclusion from its stipulation are common in Japan and the USA, in the case where sprinkler and smoke control equipment has been installed and other measures for the prevention of initial fire spread are adopted. Stipulations for mitigation are also included in the current EIT standard, however, these mitigation measures should be stipulated with consideration as to the reliability of the maintenance level of the active system.

Table 10.6: Requirements for Noncombustible Interior Finish

Items			EIT			BSL			IBC & IFC		
						Fireproof	Quasi-fireproof	Other			
Wall and Ceiling	Target Building	Hotel, hospital, multi-story housing	Every building			3 stories building with 300m^2 or more in total floor area *1	2nd floor with300m^{2}or more*1	200m^2 or more in total floor area	Every building		
		Dept. store				3 stories building with 1,000m^2 or more in total floor area	2nd floor with 500m^2 or more	200m^2 or more in total floor area			
		Theater				Stage with 400m^2 or more	Stage with 100m^2 or more	Stage with 100m^2 or more			
		Factory				Every building					
		Office, school				Refer to the general.					
		General	-			1) 1 story: more than 3,000m^2 2) 2 story: more than 1,000m^2 3) 3 stories: more than 500m^2 2) Underground floor, floor having fire equipment, and 50m^2 room without window			-		
	Required Material	Part	Habitable Room	Exit	Evacuation Route	Habitable Room		Aisle and Corridor	Habitable Room	Exit	Exit Access
		Wall	Mainly, C-I	Mainly, C-II	Mainly, C-III	Fire retardant material (except a part lower than 1.2m from a floor surface) (Quasi-noncombustible material for factory, underground floor, floor having fire equipment, and floor without window)		Quasi-noncombustible material	1)T-B: Hospital, theater 2)T-C: Other 6 building uses	1)T-A: Building use other than 2) 2)T-B: Multi-story housing, factory	1)T-A: Theater 2)T-B: Building uses other than 1) and 2) 3): T-C: Factory
		Ceiling				Fire retardant material (Quasi-noncombustible material for 3rd floor or higher) (Quasi-noncombustible material for factory, underground floor, floor having fire equipment, and floor without window)		Quasi-noncombustible material			
Floor	Part		Exit and evacuation route			No specification			Exit and evacuation route		
	Required Material		1) Hospital: Class A 2) Office, hotel, multi-story building: Class B			No specification			1) Class II: Theater, office, school, dept. store, hotel, and multi-story housing 2) DOC FF-1"pill test": the others		
Excluded Parts			Materials with 0.9mm or less in thickness			A part having both of automatic sprinkler system and smoke exhaust system.			Materials with 0.9mm or less in thickness		

Source: JICA Study Team

Note: *1 - A part having 100m^2 or less and divided by fire separation is excluded. In case of multi-story housing, the floor area is defined 200m^2.

Table 10.7: Fire Testing for Materials of Noncombustible Interior Finish

Item	ISO	BSL	IBC/IFC&EIT
Basic Requirement	No specification	1) No combustion 2) No damage to reduce fire safety 3) No generation of smoke and toxic gasses that obstruct evacuation	1) Flame spread velocity less than specified value 2) Smoke generation volume less than specified value
Standard	Noncombustibility Testing (ISO1182) and Ignitability Testing (ISO5657) (as for reference)	1) Noncombustible material: Noncombustibility testing and Ignitability testing 2) Quasi-noncombustible material and Fire retardant material: Calorific testing	1) Type A, B, C: ASTM E 84 2) Class I, II: NFPA 253
Duration of Heating	1) Noncombustibility Testing: 30 minutes 2) Ignitability Testing: 15 minutes	1) Noncombustible material: 20 minutes 2) Quasi-noncombustible material: 10 minutes 3) Fire retardant material: 5 minutes	10 minutes
Noncombustibility Testing	(ISO 1182)		
Testing Method	1) Specimen: 45 mm (diameter)x 5cm (height) 2) Heating method: electric heat 3) Temperature: 750 degree	1) Specimen: 44 mm (diameter)x 5cm (height) 2) Heating method: electric heat 3) Temperature: 750 degree	No specification
Criteria	1) Temperature rise: Max. furnace temperature (T_m) - Final furnace temperature (T_f) 2) Mass loss (Ratio of reduced weight in percentage) 3) Flaming (Duration of sustained flaming): a period of 5 seconds or less	1) Temperature rise in furnace: Final temperature +20K or less 2) Ratio of reduced weight: 30% or less	No specification
Ignitability Testing	(ISO5657)		
Testing Method	1) Specimen: 165 mm in square/ 7cm in thickness 2) Heating method: Radiant electric heater with 50kW/m^2	1) Specimen: 99mm in square/ 5cm in height 2) Heating method: Radiant electric heater with 50kW/m^2	No specification
Criteria	1) Monitoring of time for ignition	1) Calorific value: 8MJ/m^2 or less 2) No crack and hole penetrating the specimen 3) Heating velocity of 200kW/m^2 for a period of 10 seconds or less	No specification
ASTM E84			
Testing Method			1) Specimen: 7.32m (length) /51mm (thickness) 2) Monitoring the conditions after the ignition
Criteria		(Flame spread velocity: as for reference) 1) Noncombustible material:1-10 2) Quasi-noncombustible material:11-40 3) Fire retardant material:41-70	1) Flame spread velocity a) Type A: 0-25 b) Type B: 26-75 c) Type C: 76-100 2) Smoke generation velocity: 0-450
NFPA253			
Criteria			Radial heat volume (watt/cm^2) 1) Class I: 0.45 or more 2) Class II: 0.22 or more

Source: JICA Study Team

10.2.4 Use of Noncombustible Furniture and Goods

Th use of noncombustible furniture and objects should be stipulated, because the effect of preventing fire spread by stipulating the use of noncombustible interior finish is greatly reduced, once a large amount of combustible objects are brought into buildings.

The detail stipulations for furniture and objects are prepared in the USA, and they cover a large range of furniture and objects. On the other hand, in Japan, the coverage of stipulations is limited to the routes of fire spread such as curtains, carpets, etc.

It is ideal to designate rooms requiring noncombustible furniture and objects with the detail classification as seen in the USA, but it is realistic for Thailand to introduce the stipulation limited the parts relating to fire spread routes, as used in Japan.

In principle, the target types of building in the stipulation of using noncombustible furniture and objects should be the same as the ones in using noncombustible interior finish. Where noncombustible objects are placed, it is expected to strengthen the management and operation system by building owners.

Table 10.8: Requirements for Goods in a Building

Item		MR	EIT	BSL & FSL	IBC and IFC
Target Building	General	No specification	No specification	High-rise building higher than 31m	No specification
	Hotel, theater, hospital			Every building	Every building
	Office, Factory			Refer to the general	No specification
	School			Refer to the general	Every building
	Multi-story housing			Refer to the general	Every building
	Dept. store			Every building	No specification
Subjected Goods				1) Curtain, cloth blind, black curtain, carpet, exhibition plywood, and drop curtain 2) Curtain, plywood, and scene of stage	1) Foam plastic 2) Movie screen 3) Decoration hanged from ceiling and wall 4) Furniture with leather and clothes 5) Mattress 6) Natural tree 7) Leather containing toxic ingredients 8) Storing space of clothes in corridors and lobbies 9) Teaching materials and handcraft products 10) Curtain
Evaluation	Evaluation Criteria			Conditions after ignition: 1) Flammable time: 20 seconds or less until completion of flammable combustion 2) Inflammable time: 30 seconds or less until completion of inflammable combustion 3) Carbonized area: $50cm^2$ or less until completion of combustion 4) Carbonized length: 20cm or less until completion of combustion At least 3 times of the contact of fire to melt goods.	1) Foam plastic: Calorific value 100kW or less (UL1975) 2) Movie screen: Class B (NFPA 701) 3) Decoration hanged from ceiling and wall: Fire resistance (NFPA 701) 3) Furniture with leather and clothes: Class I (NFPA 260) 4) Mattress: Carbonized length 5.1cm or less
	Criteria by Good			1) All criteria for melted goods 2) Criteria of 1) and 4) for carpet 3) Criteria of 1) and 3) for others	-

Source: JICA Study Team

10.3 PREVENTION OF FIRE SPREAD (INTRODUCTION OF FIRE SEPARATION)

The fact that there was no fire spread preventive measures in the buildings caused the extensive damage by the fires of the doll factory and the hotel. The concept of fire separation has been partially but not systematically introduced in MR 33 and MR 55 as listed below.

- Noncombustible materials for walls and ceilings in kitchens (MR 33),
- Installation of plain concrete walls for Row Brick Buildings and Row Houses (Article 16 of MR 55),
- Separating every five houses with a fire preventive wall for Row Brick Buildings and Row Houses (Article 17 of MR 55), and
- The use of fire resistance materials for floors and walls of kitchens (Article 18 of MR 55).

The points to be addressed for systematically introducing the fire separation to secure prevention of fire spread are shown below.

i) Types of Fire Separation

There are four types of fire separation: 1) Area Separation, 2) Vertical Opening Separation, 3) Mixed Use Separation, and 4) Separation at Incidental Use Area. Area Separation is to subdivide a floor into a room or compartment with a definite floor area. Vertical Opening Separation is to subdivide continuous parts consisting of plural floors such as atrium, elevator shaft, staircase, etc. Mixed Use Separation is to subdivide a complex building into parts of single building use. Separation in a Incidental Use Area is to subdivide parts which are important in safety of human life and property.

It is a principle of fire separation that the above subdivisions consist of fireproof walls and slabs. In the case of large floor areas, it should be subdivided by a fire prevention method such as fire shutters to form fire separation when the fire is broken out.

Both Japan and the USA stipulate vertical opening separations, mixed use separations, and separation of incidental use areas. Although area separation is required in Japan, it is replaced by separation at incidental use area, which is applied for tenant spaces, housings, and exits in the USA.

Fire separation that enhances passive systems is preferable in Thailand, because it is difficult to expect the same level of fire fighting capacity as the one in the USA and to establish proper maintenance of the systems, which are necessary for active system to have continual and correct operation when required.

Among four kinds of fire separation, vertical opening protection has the highest priority to be introduced into the ministerial regulations. The vertical opening protection aims to enclose staircases by fire separation and it is indispensable for the securing of evacuation safety and the confining fires within the certain number of floors. The four developed countries commonly specify this protection. It is strongly recommended to require vertical opening protection.

The scale of fire separation should be comprehensively determined while considering the fire resistance time, calorific value of combustible objects, fire fighting capacity, possibility of earthquake, and mitigation through the installation of sprinklers. It is recommended that the scale of vertical opening protection will be based on cubic volume of openings as stipulated in UK and Australia, as well as based on the number of floors as stipulated in Japan.

Table 10.9: Requirements for Fire Separation

Item		MR	EIT	BSL			IBC
Area Separation	Class.	No specification of the area separation	No specification of the area separation	Quasi-fireproof	Fireproof	11th floor or higher	No specification of the area separation
	Hotel			500-1500	1500	100	
	Office			500-1500	1500	100	
	Theater			500-1500*1	1500*1	100	
	Hospital			500-1500	1500	100	
	School			500-1500	1500	100	
	Factory			500-1500*1	1500*1	100	
	Multi-story housing			500-1500	1500	100	
	Dept. Store			500-1500	1500	100	
	Note	-	-	*1:Able to excluded if inevitable			-
	Alleviation	-	-	Alleviation of specified floor area to twice by installment of sprinkler system			-
Vertical Opening Protection		Escape staircase	Escape staircase	Building having underground floor or a habitable room in 3rd floor or higher 1) Staircase and elevator shaft 2) Atrium			Escape staircase
Mixed-use Separation		No specification	Specified	Fire separation by the following classification 1) school, theater, movie theater, play theater, public theater, assembly hall, market, public bath 2) vehicle factory 3) Dept. store, multi-story housing, boarding room, hospital, warehouse			Specified
Separation at Incidental Use Area		1) Kitchen 2) Wall of Row brick building and Row house 3) Row building, Row brick building, Row house: Dividing into 5 housing units or less by fire separation	1) Boiler and substation room 2) Warehouse 3) Generator room 4) Electric distribution room 5) Air-conditioning equipment room 6) Elevator machine room 7) Emergency ventilation machine room 8) Battery room 9) Fire pump room 10) Communication room 11)Kitchen 12)Sleeping room (hotel, residential) 13)Floor separation of underground floors 14)Exit access 15)Exit (30 occupants or more)	1) Storage of hazardous and treatment facilities 2) Theater, movie theater, play theater, public theater, assembly hall, hospital, clinic, hotel, multi-story housing, school, gymnasium hall, dept. store, market, café, night club, bar, dance hall, play ground, warehouse, vehicle factory 3) Kitchen, fire fighting control room, corridor, horizontal exit, confined horizontal exit (recommended)			1) Electric, boiler, cooling machine rooms 2) Warehouse 3) Room with heating furnace 4) Hospital room for mental patient 5) Housing unit, guestroom, tenant space, corridor 6) Incinerator, washing, paint selling, laboratory rooms 7) Job training room 8) Parking 9) Exit and horizontal exit

Source: JICA Study Team

Table 10.10: Fire-resistant Rating of the Fire Separation

Type of Separation	Name of Structure	BSL	IBC	EIT Standard
Separation of a Building	Fire Wall	20 minutes	2-4 hours by the classification of building	No specification
Area Separation	Fire Barrier (wall and floor)	1hour	No specification	No specification
Vertical Opening Protection	Fire Barrier (wall and floor)	45 minutes	Escape staircase: 1) 2 hours for 4th floor or higher 2) 1 hour for 3rd floor or lower	1) Escape staircase: a) 3rd floor or less: 1 hour b) 4th floor or higher: 2 hours 2) Dust chute and linen chute: 1 hour 3) Elevator shaft: 2 hours
Mixed-use Separation	Fire Barrier (wall and floor)	45 minutes	1 - 4 hour by a combination of the classification of building	1 - 4 hour by a combination of the classification of building
Separation at Incidental Use Area	Fire Barrier (wall and floor)	1hour	1) Separation at incidental use area: 1 - 2 hours 2) Evacuation route: 1 hour 3) Horizontal exit: 2 hours	1) Incidental use area: 1 - 4 hours 2) Underground: 4 hours 3) Exit access: 1 hour 4) Exit a)3rd floor or less: 1 hour b)4th floor or higher: 2 hours
	Fire Partition (wall)	No specification	1 hour for housing unit, guestroom, tenant space, and corridor	No specification

Source: JICA Study Team

ii) Fire Separation at Openings and Penetrated Parts

Fire separation inevitably has openings and penetrated parts for an entry by occupants (doors), ventilation/lighting (windows), and supply/treatment (pipe shafts). These openings and penetrated parts have to be protected by fire preventive measures that ensure effectiveness of fire separation to prevent fire spreading. As seen in the fires at the doll factory and the hotel, spaces for pipes and elevators became the route for the spread of fire. It is crucial that proper measures at the openings of fire separation is specified in fire codes.

Air conditioning and pipe shafts penetrate fire separation barriers, therefore it is necessary to make air conditioners and pipe shafts fireproof and to fill any gaps in the penetrated part with noncombustible materials. Openings such as windows and doors are also required to have fire resistance. With regard to this point, MR 33 stipulates fire resistance in the conveying route of garbage and air conditioner ducts and the installation of fire dampers inside the ducts. However, MR 33 does not introduce the concept of the fire separation and it does not stipulate the use of noncombustible materials at the penetrations of the air conditioner ducts.

In Japan, fire codes specifies use of noncombustible materials, such as mortar, in the penetrated parts of fire separation barriers. Fire-resistance rating for protection at openings is required at lower level than that of fire separation barriers. On the other

hand, the fire-resistance rating for openings is the same as that stipulated fire preventive walls in the IBC of the USA, which is stricter than that stipulated in Japan. The lesser fire resistance time allowed in Japan originated from the requirement for spandrels to be constructed around the openings.

Table 10.11: Fire Protection at Openings and Penetrated Part of Fire Separation

Part		MR	EIT	BSL	IBC
Opening	Equipment	No specification	Fire-resistance rating same with wall and floor is required.	1) Area separation a) Fireproof building: 1 hour b) 11th floor or higher: 20 minutes 2) Vertical opening protection: 20 minutes 3) Mixed-use separation: 20 minutes 4) Separation at incidental use area: automatic closing device and flame resistance	1) Fire Wall and Fire Barrier with 1 - 4 hours rating: 1.5 - 3 hours 2) Fire Barrier with 1hour rating: 0.75 - 1 hours 3) Fire Partition with 1 hour rating: 0.33-0.75 hour
	Structure	No specification		Spandrel is required as follows: 1) Fire resistant wall and floor: 90 cm or more in height and width 2) Eaves and sleeve wall: 50 cm or more in length	Specifying the size of window and fire-resistant rating.
Penetrated Part		No specification	Filling by noncombustible materials at the fire-resistant rating same with fire separation.	Filling by noncombustible materials	Filling by noncombustible materials at the fire-resistant rating same with fire separation.
Duct and Pipe		1) Fire damper is required 2) Noncombustible materials for piping	Fire damper is required	Fire damper is required as follows: 1) Automatic closing device 2) Flame resistance	Fire damper is required as follows: 1) A part within 3-hours rating: 1.5 hours 2) A part more than 3-hours rating: 3 hours
Shaft and Dust Chute		Noncombustible materials of duct chutes	1) Dust chute and linen chute: 1 hour 2) Elevator shaft: 2 hours	Fire resistance is required at duct spaces and elevator shafts.	Fire resistance is required for duct spaces.
Opening of External Wall		No specification			0.75-1.5 hours by the fire-resistant rating of an external wall

Source: JICA Study Team

10.4 EVACUATION

The principle of evacuation under a fire condition is to secure safe movement for the occupants to move from the inside of the building to a safe area, outside of the building before the fire gets too dangerous. The danger is that the smoke descends to a height where it hinders the evacuation. Therefore, it is essential to specify in the fire codes that the evacuation can be completed before the smoke descends to the hazardous height.

In high-rise or large scale buildings, with a large number of occupants and where occupants are easily brought to confusion by an evacuation, it is recommended that the fire codes specifies an evacuation plan for building assessment. The evacuation plan will be required to cover all evacuation routes from the building to the safe areas outside the building. The evacuation routes are required to have the following performances.

- Sufficient capacity for the number of occupants,
- Continuity from any part of a building to the safe area,
- Clarity for easy understanding,
- Redundancy,
- Fire resistance,
- Smoke control, and
- Ease of travel for walking (brightness, flatness, and uniformity of steps), etc.

Moreover, it is necessary to prepare countermeasures when in the case of disabled person's occupancy who are unable to evacuate themselves. The evacuation plan should also be formulated to cater for any other special characteristics of the occupants.

The following points should be addressed for improving the requirements of the evacuation.

10.4.1 Proper Evacuation Routes

Both MR 33 and MR 55 do not regulate the whole path of evacuation routes from all points of a building to the safety area, although these regulations specify the requirement for evacuation staircases for a building larger than a certain scale.

It should be noted that the evacuation route passing through sleeping rooms, as well as unsafe evacuation staircases, mainly caused the extension of damage in the fire of the hotel. Fire codes should specify requirements to cover entire evacuation routes.

It is important to define evacuation routes with the following three portions: 1) Exit access, 2) Exit, and 3) Exit discharge. The "Exit access" is the portion of an

evacuation route from any occupied point in a building to an exit. The "Exit" is the portion of an evacuation route that is separated from another interior space of the building by a fire resistant structure and opening protection. It has an access to the outside of the building. The "Exit Discharge" is the portion of an evacuation route between the termination of an exit and a public way which is a safe area outside the building.

In addition, evacuation routes should be specified with the following requirements.

- Continuity where occupants can evacuate to a safe area without straying from the evacuation route,
- Redundancy by provision of multiple evacuation routes in a building,
- Safety to sustain fire and smoke resistance at all evacuation paths, and
- Friendliness for walking by flatness and no slipperiness for the horizontal evacuation routes and a constant size of the rise and tread of stairways.

In the Building Standard Law of Japan, main facilities of evacuation routes are focused on the escape stairway and exit discharge. Since the BSL regards evacuation routes in the vertical direction, the examination of the fire prevention plan is required for horizontal evacuation routes of a certain scale of buildings. The evacuation routes are recommended to be the same path of daily travel flow in a building.

On the other hand, there are three portions in the definition of evacuation route in the IBC of the USA: 1) Exit access passageway, which is the path to exit, 2) Exit is the evacuation route, and 3) Exit Discharge, which is the path to a public way. Separating the exit from the daily route, it includes both horizontal and vertical evacuation routes.

As such, there is a large distinction in the provision of evacuation route between Japan and the USA. Of the two different concepts for evacuation routes in these countries, the ability to consolidate the evacuation route and the daily route into one, as allowed in as Japan, is worth considering because the consolidation allows less confusion to evacuees fleeing from a fire.

i) Sufficient Capacity of Evacuation Routes

The evacuation routes should be wide enough (capacity) to allow occupants to evacuate safely.

It is stipulated that buildings more than four stories should have at least 1.5m width corridors, 0.8m width staircases inside buildings, and 0.6m width outside stairways by stipulation of MR55. The minimum width for both inside and outside stairways in high-rise and large scale buildings is set to 0.9m in MR 33, however, the width of 0.6m for outside stairways is narrow for daily use and it cannot work, as expected, in cases of great confusion. Other stipulations for the capacity are too inflexible to

cover the varieties of building types and still attain the expected performance. The required width of corridors and stairways should be determined by the number of occupants based on scale and use of buildings.

The fixed width of the buildings inspected in the Study was not attained, due to intrusion by opened panels of fire doors and projections of beams and columns. It is also reduced by obstacles such as pipes. There were a number of narrow spaces hampering smooth evacuation. It is expected to set an upper limit to obstacles or projections, which would narrow the width of stairways and corridors.

Table 10.12: Occupant Density (Occupant/m^2)

Item	MR	EIT	BSL	IBC	Comparison to BSL	
					EIT	IBC
Hotel	No specification	0.06	0.16	0.054	0.35	0.34
Office		0.11	0.125	0.108	0.89	0.86
Theater		1.67(assembly) 0.80(dance hall)	1.5	1.538(Removable seat) 2.153(standing seat) 0.718(table, chair)	1.11	1.03
Hospital		0.14	No specification	0.045(inpatient) 0.108(outpatient) 0.090(hospital room)	-	-
School		0.50(classroom)	0.70	0.538(classroom)	0.71	0.77
Factory		No specification	No specification	0.108	-	-
Multi-story Housing		0.06	0.06	0.054	0.93	0.90
Department Store		0.50(basement fl.) 0.40(1st fl.) 0.22(2nd fl. or higher)	0.50	0.359(basement fl.) 0.179(other floor)	1.00 0.80	0.72 0.36

Source: JICA Study Team

Table 10.13: Width of Evacuation Route

Item		MR	EIT	BSL	IBC
Corridor	Hotel	1.5m	At least 90cm and 0.5cm/occupant (1.3cm/occupant for hospital)	1.6m (1.2m)	1) At least 91cm: 50occupants or less 2) At least 114cm: more than 50 occupants 3) 0.5cm/occupant(0.4)
	Office				
	Theater				
	Hospital				
	School			2.3m (1.8m)	
	Factory				
	Multi-story Housing			1.6m (1.2m)	
	Dept. Store				
	Note	(Specified for the daily use)	Total width of evacuation routes	Used for the daily use and emergency. Value in () is for one-side corridor	Total width of evacuation routes Value in () is for the part with an automatic sprinkler system.
Stairway	Indoor	4th floor or higher:80cm High-rise:90cm	At least 90cm and 0.8cm/occupant (1.5cm/occupant for hospital)	140cm (0.6cm/m^2 in total for dept. store)	1) At least 91cm: 50occupants or less 2) At least 114cm: more than 50 occupants 3) 0.8cm/occupant(0.5)
	Outdoor	4th floor or higher:60cm High-rise:90cm	Same with indoor stairways	90cm	Same with indoor stairways
	Note	-	Total width of evacuation routes	-	Total width of evacuation routes Value in () is for the part with an automatic sprinkler system.
Discharge Coefficient	Horizontal Direction	No specification	No specification	90 persons/m/minute	107 persons/m/ minute
	Vertical Direction	No specification	No specification	80 persons/m/ minute	80 persons/m/ minute

Source: JICA Study Team

ii) Proper Provision of Evacuation Route and Securing of its Redundancy

To allow occupants to obtain a safe evacuation route (Exit) from any point of a building within an appropriate time, the evacuation routes need to be properly placed. To achieve this, it is necessary to stipulate the maximum walking distance to an exit (Maximum Exit Access Travel Distance), the distance between evacuation routes, and the maximum distance to the deadend of corridors that are not evacuation routes (Maximum Length of Deadend).

Moreover, to secure redundancy of evacuation routes for a part of building with a certain number of occupants or a certain floor area, it is necessary to specify the necessity of two or more evacuation routes (Multiple Evacuation Routes) and maximum length of overlapped travel distance of two evacuation routes to the exits (Maximum Common Path of Exit Access Travel).

Ministerial Regulation No. 33 requires 60 m for a maximum exit access travel distance and the installation of more than two escape stairways (multiple evacuation routes) in high-rise buildings. However, the maximum exit access travel distance of 60 m in MR 33 is rather long, even if alleviation by installing sprinklers is taken into account. On the other hand, the buildings and/or parts with large floor area excluded from requirements of MR 33 should have the multiple evacuations. To achieve this, it is desirable that redundancy of evacuation routes is required based on the number of occupants.

In advanced countries, the multiple evacuation is required for a part with a certain number of occupants which is estimated by a floor area of a habitable room and/or a floor. The BSL in Japan specifies the necessity of the multiple evacuation routes based on the floor area that can be converted to a number of occupants by a occupants' density (person/m^2) and useful for architects to make a floor layout. Requirements of the BSL imply the number of occupants to determine the redundancy. The target number of occupants for the multiple evacuation routes is about 50, but the number fluctuates by the building use.

The maximum walking distance is also different for each country. There is significant distinction between Japan and the western countries of the USA, England, and Australia. The distance is set between 20m and 50m in Japan, because the exit is defined as the escape stairway. On the other hand, the exit of western countries includes corridors/aisles. The distance is set between 61m and 91m in the USA, and between 30m and 40m in Australia. The stipulation of the maximum walking distance in Japan is stricter than that in western countries.

A maximum common path of exit access travel and maximum length of deadend are generally set to half of the maximum walking distance and less than 10 m, respectively.

Table 10.14: Multiple Evacuation Routes

Classification	MR	EIT (Occupant)	BSL (m^2 and (occupant))			IBC (occupants)
			5th floor or less		6th floor or higher	
			Fireproof and Quasi-fireproof	Other		
Hotel	23m or higher	10	200 (32)	100 (16)	Every building	10
Office		30	One upper floor of an escape floor:400 (50) Other floor:200 (25)			50 (1 階) 30 (2 階)
Theater		50	Every building			50
Hospital		5	100	50		10
School		50	One upper floor of an escape floor: 400 (280) Other floor: 200 (140)			50
Factory		-	One upper floor of an escape floor:400 Other floor: 200			50
Multi-story Housing		10	200 (12)	100 (6)		10
Dept. Store		10 (basement and 2nd floor or higher) 50 (1st floor)	One upper floor of an escape floor: 400 (200) Other floor: 200 (100)			50 (1st floor) 30 (2nd floor)

Note: Number of occupants of BSL is assumed from floor area by occupant density.
Source: JICA Study Team

Table 10.15: Maximum Exit Access Travel Distance and Maximum Common Path of Exit Access Travel

Item		MR	EIT	BSL			IBC
				14th fl. or less		15th fl. or higher	
				Fireproof and Quasi-fireproof	Other	Fireproof and Quasi-fireproof	
Max. Exit Access (m)	Hotel	60	30 (60)	50 (60)	30	40 (50)	61 (76)
	Office		60 (91)	50 (60)	40	40 (50)	61 (91)
	Theater		45 (60)	50 (60)	40	40 (50)	61 (76)
	Hospital		45 (60)	50 (60)	30	40 (50)	61 (76)
	School		45 (60)	50 (60)	40	40 (50)	61 (76)
	Factory		-	-	-	-	91 (122)
	Multi-story Housing		30 (60)	50 (60)	30	40 (50)	61 (76)
	Dept. Store		45 (60)	30 (40)	30	20 (50)	61 (76)
Max. Common Path (m)	Hotel	No specification	No specification	25 (30)	15	20 (25)	23
	Office			25 (30)	20	20 (25)	23 (30)
	Theater			25 (30)	20	20 (25)	23
	Hospital			25 (30)	15	20 (25)	23
	School			25 (30)	20	20 (25)	23
	Factory			25 (30)	20	20 (25)	23
	Multi-story Housing			25 (30)	15	20 (25)	23
	Dept. Store			15 (20)	15	10 (15)	23
Alleviation		No alleviation (every targeted building has sprinkler systems)	By installment of sprinkler systems. (Value in () is for a part with sprinkler systems.)	By noncombustible interior finish. (Value in () is for a part with sprinkler systems.)			By installment of sprinkler systems. (Value in () is for a part with sprinkler systems.)

Source: JICA Study Team

10.4.2 Proper Installation of Escape Stairway

Both MR 33 and MR 55 stipulate the use of outside and inside escape stairways. They also stipulate inside stairways (staircases) with smoke control systems of either pressurization or gravity type for high-rise buildings. In the fire of the Royal Jomtin Hotel, the functions of the evacuation routes were not fulfilled on the escape stairways because smoke penetrated to these egress routes. It is expected to improve the pertinent control packages for ensuring smoke control in the escape stairways.

However, it is essential for safety of escape staircases that smoke control is executed at a part of route to a staircase rather than within the staircase. Moreover, it is difficult to sustain pressure with pressurized smoke control systems, and satisfying conditions such as building design adaptable to the pressurized control system is vital to attain the desired effect.

i) Requirement for Escape Staircases (inside Buildings)

The MRs stipulate various points for escape stairways, however, the following improvement is needed.

- Gravity smoke exhaust in a staircase has no effect to prevent smoke intrusion into the staircase. On the other hand, it is difficult for pressurization systems within staircases to sustain air pressure, when evacuee continuously open a door to the staircase. It may results in reduction of air pressure within the staircase and reliability of evacuation routes. The pressurization system is costly, due to large cubic volume of pressurization and structure of high air-tightness. It is recommendable to specify smoke-proof staircases with a balcony or vestibule where smoke control is executed. The smoke control by pressurization or exhaust is required for the vestibule, while it is not necessary for the balcony directly opened enough to outside. The smoke-proof staircase needs structure with high air-tightness and pressurization/exhaust that is smaller than an escape staircase with a smoke control system. It also has advantages: 1) reduction of construction/maintenance cost for pressurization/exhaust systems and 2) improvement of reliability (by smoke control at a part in front of staircases). Disadvantage of smoke-proof staircase will be reduction of profitable floor areas by installation of vestibules or balconies for building owners/operators.
- The periodic inspection by starting up pressurized smoke control systems.
- The installation of fire resistant barriers in openings, such as fire doors and fixed-sash type with wired glass.
- The installation of handrails on both sides for both right and left handed persons.

ii) Requirement for Installation of Smoke-proof Staircases

The placement of smoke-proof staircases is required for high-rise buildings over a certain level in height. The provision of at least one smoke-proof staircase is required in the EIT standard, but every escape staircase should be upgraded to smoke-proof staircases. The BSL in Japan specifies through stairways (continuous to a safety floor) for buildings having four floors or less, escape stairways for buildings over four floors, and smoke-proof staircases for buildings with 15 floors or more. On the other hand, the IBC of the USA requires escape stairways for buildings having two floors or more and smoke-proof staircases for buildings of 23m or higher (or around 16 floors). As such, any building having 15 or 16 floors are suitable for the criteria of providing smoke-proof staircases.

iii) Outside Escape Stairways

Outside escape stairways have smoke resistance higher than staircases. However, the outside stairways have a danger of evacuees' falling and attention must be paid to this, especially at the upper floors. It is recommended to specify a suitable height limit of 22.86 m and six floors, or less for outside escape stairways, as applied in the USA. In addition, requirements for the outside escape stairways should specify minimum distance from openings around stairways and fire-resistance rating of the openings.

Table 10.16: Type of Escape Stairways

Type	MR	EIT	BSL	IBC
Through Stairways	No specification	No specification	2nd floor or higher	No specification
Escape Staircase	1) 4th floor or higher: 1location 2) 23 m or higher: 2 locations	2nd floor or higher	5th floor or higher	2nd floor or higher
Smoke-proof Staircase	No specification	5th floor or higher (at least one location)	15th floor or higher (At least one location for 5th floor or higher of dept. store.)	23m or higher from the height of a fire engine
Outdoor Escape Stairway	No height limitation	No height limitation	No height limitation	6th floor and 22.86m or less

Source: JICA Study Team

Table 10.17: Form of Escape Stairways

Item		MR	EIT	BSL	IBC
Through Stairway		No specification	No specification	Continuity to the end of evacuation route	No specification
Escape Staircase	Fire Resistance	Specified	Specified	Specified	Specified
	Opening	No specification	No specification	1) Sleeve wall with 50cm or more in length, or 2) Distance with 90cm or more from other openings	Fire-resistant rating is required.
	Fire Door	1) Automatic closing device 2) Fire resistance	1) Automatic closing device 2) Fire resistance	1) Automatic closing device 2) Fire-resistance rating 3) Inter-linkage with smoke or heat detector	1) Automatic closing device 2) Fire-resistance rating
	Lighting	Emergency lighting	Emergency lighting	1) Emergency lighting or 2) Natural lighting	1) Emergency lighting or 2) Natural lighting
	Ventilation	1) Opening of 1.4m^2 or 2) Pressurized system with 3.86P	No specification	No specification	Specified
	Handrail	At one side	At both sides	At both sides	At both sides
Smoke-proof Staircase	Basic Condition	No specification for smoke-proof staircase	Same with escape staircase	Same with escape staircase	Same with escape staircase
	Vestibule		Vestibule or balcony	Vestibule or balcony with 5 m^2 or more (Area of staircase and balcony is more than 3/800 of a floor area for dept. store and theater)	Vestibule or balcony
	Smoke Control		Specified	Required at a vestibule by smoke exhaust or pressurized system	Specified
Outdoor Escape Stairway		No specification of a distance from an adjacent opening.	Fire resistance at an adjacent opening.	Distance of 2m or more from an adjacent opening.	Fire resistance at an adjacent opening.

Source: JICA Study Team

10.4.3 Horizontal Exit (Exit strengthening the redundancy and smoothness in evacuation)

The followings are related to items, which strengthens redundancy and smoothness of evacuation routes stipulated in the current building control act.

(1) The current act specifies the evacuation facilities for buildings over 10,000m^2 in total floor area and 23m in height. However, evacuation for buildings with 100,000 m^2 floor area and 100m in height is much more difficult than one with 10,000m^2 in floor area and 23m in height. In the case where occupants inside a high-rise building evacuate at the same time, the stairways do not function properly. Occupants on a floor with large floor area have to stay at the floor, even if they start the evacuation by a floor to another.

(2) The stipulation is not in concert with the characteristic of the occupants. Stipulations, for occupants unable to evacuate themselves, such as disable or elderly persons, for occupants staying in an operation room at hospitals, and for

occupants staying in bed, should be prepared.

(3) The stipulation for a rooftop safety area has been already prepared to secure a connection route between escape stairways. In addition, the space is strong enough to resist smoke, as it is directly opened to outside. However, the stipulation is still weak in the technical aspects such as the fire-resistance rating of floors.

To improve the above problems, the measures to secure redundancy and smoothness are recommended as below. However, the measures should be considered as to secure a temporary safe area, as evacuation has to be completed by arriving at safe areas outside buildings. To achieve this, these measures should have an access for rescue from outside by firefighters. In Japan, these measures are applied through technical assessment by experts, but not mandatory requirements in the Building Standard Law. As such, the introduction of these recommended measures should be limited to large-scale/high-rise buildings and buildings having many occupants weak in evacuation.

i) Introduction of Safe Separation

For (1) above, adoption of a safe separation is effective. In Japan, it aims to form temporary safe areas in evacuation routes where evacuees stay for a time. The temporary safe areas should be formed by noncombustible interior finish and fire resistant walls with fire protection at openings and equipped with smoke control systems. The required area of refuge is estimated by the number of occupants, who may tend to stay, in conditions where evacuation is executed by a floor to another.

ii) Introduction of Horizontal Exit

For (1) and (2) above, adoption of the horizontal exit is also effective. More than two fire separations are prepared for a single floor. Occupants temporarily move to escape stairways after temporarily staying at one of the safe separations. The horizontal exit is effective for the cases where floor area and the number of occupants are large and self-evacuation is difficult. The followings should be taken into account:

1) The necessity to provide the sufficient floor area at any of the separations accommodating inflow of occupants from another separations.
2) No increase of widths of escape stairways upon conditions where temporary safe area is properly secured.
3) The necessity to provide fire fighting access and communication equipment, and
4) To preferably include parking space for wheelchair users space in the area.

iii) Introduction of a Confined Horizontal Exit

To (2) above, the adoption of a confined horizontal exit is also effective. It enables the occupants, who are not able to move at all, to stay in rooms such as an Intensive Care Unit (ICU), an operating room, etc for a long time. The confined area needs to have fire and smoke resistance with the prolonged durability in systems such as air-conditioning and electricity until extinguishing the fire. Moreover, it should have fire-fighting access and communication activities.

iv) Introduction of an Effective Balcony on Evacuation

To (2) above, it is effective to use an effective balcony for the evacuation (balcony linking) in the buildings with sleeping rooms such as hospitals, hotels, residences, and the buildings containing disabled people. The types of balconies are seen on buildings in Japan. The balcony linking has two types; Surrounding Type and Partial Type. The former connects the balconies at the circumference of a building and secures a multiple evacuation route. The latter is for evacuation through balconies and adjoining dwelling units. Both types of balcony linking are to secure evacuation routes to exits through balconies. It should be noted that the balcony linking is alternatively recommended in the BSL of Japan and evacuation routes have to be formed by corridors and/or aisles as much as possible.

Although the balcony linking has advantage to secure a route, which is hard to be overcome by smoke, it has disadvantages that there are infringements of privacy and restrictions in building design.

10.4.4 Exit Discharge

It is expected to provide concepts that secure space to assist occupants to evacuate to the safe area. Although provision of paths to the exit termination is stipulated in the current act, evacuation routes from the termination to a public way outside a building are not stipulated. A 6 m width or greater space around high-rise and large-scale buildings is required, but this requirement is for the access of fire engines and to provide spaces where fire engines can get closed to the building. The current act also specifies setback from a front road to the wall of a building and the interval space to the next building, but these distances do not aim to secure the evacuation route. Based on a concept that evacuation route should be secured to safe areas, it is desirable to specify evacuation routes outside buildings (exit discharge).

According to the current act, over a 2m width is required for setback control, etc, so that this width is sufficient for the evacuation route. In cases where a building has not entrance directly to a front road, and it is located at the innermost part of a lot, an exist discharge should have capacity and fire resistance similar to these of exits, which connects to the exit discharge, as stipulated in the USA.

Safe areas and roads for the termination of evacuation routes are clearly defined as public ways in the USA. The stipulation in the USA specifies three points: 1) Prohibition of a re-entrance to a building, 2) Sufficient level of capacity, and 3) More than 3m separation from adjacent buildings and the site boundaries. On the other hand, a 1.5m width and accesses to a park, a public square, or an open space are basic conditions for exit discharge in Japan. As such, fire codes in both countries specify an evacuation plan that includes the route to final safe area, while these code apply different methods.

10.4.5 Locking and Direction of Open and Shut for Door

It is stipulated in the current act that doors of escape stairways at high-rise and large scale buildings must be able to be opened to outside. Although the custom of locking depends on the pattern of operation and maintenance, the building control act should specify the rules of the doors to be able to be opened easily at any time, learning from the fact that the locked doors of small-scale buildings, such as shophouses, prevented occupants from escaping from the inside and firefighters from entering from the outside caused deaths in fires.

i) Target Exit and Locking Rule

It is basic requirements that doors can be opened at any time from inside without keys in Japan. It is also stipulated that the procedure of unlocking without keys is clearly indicated in the conditions where an exit is locked for security in normal cases, but it opens as an evacuation route in the emergency situation. Two types of doorways are stipulated in Japan: 1) Doorway leading to an outside escape stairway from inside and 2) Doorway leading to the outside from an escape stairway.

A fire code in the USA also specifies that doors can be opened without a key or special knowledge. It requires that the egress doors should be easily identified, whether they are locked or not, and that doors can be unlocked and opened in an emergency in theaters which exceed a capacity of more than 300 persons. Even in houses or guestrooms accommodating less than 80 persons, the use of a chain is allowed, but it is prohibited to lock the doors with keys.

As such, it is fundamental that an exit door can be opened without a key or special knowledge at any time. In the case of locking the exit from inside, it is desirous to be able to open the door with either an automatic opening linked to the fire detection system or through the use of a manual panic bar mechanism. Since it is difficult to introduce an easy unlocking system from outside, due to security matters, it is recommendable to provide an access, such as windows, through which firefighters forcedly enter into a building.

On the other hand, control by the Labor Protection Act, etc. is necessary in order to prohibit the owners from locking doors from outside, as seen in the fire at the shophouse, otherwise deaths may occur.

ii) Direction of Door Opening

When the direction of the door opening is opposite to the evacuation travel direction, evacuees are forced to stay in front of doors and the doors could be inhibited from being opened, due to the pressure by evacuees, under panic or emergency conditions. Although the current act specifies opening direction of doors to outwards, it is expected to slightly change from "open outwards" to "open to the evacuation direction".

Open to the evacuation direction for exit doors to escape stairways and exit doors to the outside is stipulated in Japan, while the direction of door opening within evacuation routes to escape stairways is required only from the main seating area in a theater. In office buildings, the doors may open to the opposite direction to evacuation direction, where the doors face into corridors, to prevent the doors from bumping against evacuees moving along the corridors. In the USA, opening to the evacuation direction is always required.

10.4.6 Emergency Lighting and Exit Sign Facilities

Exit sign facilities are classified into two types: Exit sign illumination having lighting function and Exit sign having no illumination. While emergency lighting aims to light up target areas to the level of specified illumination intensity in cases of emergency, the exit sign illumination is illuminated at any time and aims to indicate an exit direction with the level of required brightness where evacuees can watch from a certain distance.

In Thailand, places for installation of emergency lighting and exit sign illumination are not sufficiently described in the current act. The act requires the installation of exit sign and emergency lighting at stairways for high-rise buildings, however, it requires installation of these facilities along evacuation routes for public buildings. It is desirable to require installation throughout the evacuation routes. In addition, the technical standard of materials and intensity of illumination is also required.

The installation of both emergency lighting and exit sign facilities is required for the whole part of the evacuation routes, including habitable rooms, in Japan. Emergency lighting is required for special buildings with three floors and 500 m^2 or more. It is also required for other uses of buildings having more than 1,000m^2 in the total floor area. Exit sign illumination is a preferable type of exit sign facilities. It is required at every type of exit, corridors, and seating areas for buildings over 11-stories and a floor of more than 1,000m^2. Required performance for the emergency lighting is to have 1 lux of illumination at the floor surface, at least a 30-minute power supply, fire

resistance, and installation at intervals of 20m or 30m. On the other hand, required performance of exit sign illumination is to have at least a 20-minute power supply, fire retardant abilities, the installation at intervals of within 20m or 30m, and at a height to be visible.

Emergency lighting and exit sign illumination are required throughout the whole of the evacuation routes in the USA, while places for installation of exit sign illumination is targeted at exits and their doorways. The power supply to sustain for 90 minutes is required for both emergency lighting and exit sign illumination. an illumination of more than 11 lux from the emergency lighting at the surface of floors is also required.

Both emergency lighting and illuminated exit signs are required to be installed within the whole evacuation route in both Japan and the USA. Except at doorways, the mounting height of the illuminated sign should be lower parts of evacuation routes so as to be clearly visible, where smoke layer is not easily formed. The requirement for illumination intensity and emergency power supply is different between Japan and the USA. The illumination of 1 lux is required in Japan, based on an walking velocity which can be reduced by reduction of illumination.

10.4.7 Smoke Control

The current act of Thailand specifies smoke control systems in escape staircases of high-rise buildings by the air pressure of 38.6 P for a pressurized system and 1.4m^2 for a gravity system. It also requires a gravity smoke exhaust by an opening of 1.4m^2 for 4-story buildings. Reflecting lessons from past fires, improvement of the safety in escape stairways is executed. However as mentioned above, smoke control system in escape stairways should be reconsidered and it is desirable to stipulate the control system from the systematic point of vie. The following points should be addressed.

i) Target Parts of Smoke Control

Smoke exhaust systems are required for buildings with 500 m^2 in total floor area or more in Japan. They are installed at rooms with a high potential of fire outbreak and evacuation routes. The targeted part includes more broadly than that of Thailand. Extension of the targeted parts is recommended to cover the followings.

- Rooms having possibility of fire outbreak
- Smoke control to the whole part of evacuation route including corridors/aisles and not limited to high-rise buildings
- Rooms and corridors/aisles with insufficient openings（Area of openings must be not less than one-fifty of floor area (m^2) in Japan.).

On the other hand, installation of smoke exhaust system at small-scale rooms having 100 m^2 or less cause excessive reduction of air pressure which results in malfunction

of doorways and impediment for evacuation. Therefore it is desirable that the smoke exhaust system can be excluded in a case where noncombustible materials are used for interior finish to reduce volume of smoke generation and fire-proof doors with automatic closing mechanism are installed at doorways which face to evacuation routes.

ii) Introduction of Smoke Separation

It is fundamental to form smoke separation to ensure the effectiveness of smoke control systems.

iii) Smoke Control System

Smoke control system in Japan is generally selected from two options: gravity smoke exhaust type by air supply and exhaust by buoyancy and the mechanical smoke exhaust type by gravity air supply and mechanical exhaust. It is prohibited to install both systems in the same smoke separation. there is no requirement to install pressurized smoke control systems which are already stipulated in Thailand. Introduction of the pressurized system has progressed in Japan. Introduction of the pressurized system has progressed in Japan mainly for high-rise/large-scale buildings approved by experts who evaluate the appropriateness of the system with its simulation.

The construction of the pressurized system is generally difficult to secure expected performance. It is desirable to install a combination of pressurized and exhaust systems. The former aims to prevent evacuation routes and crucial parts for fire protection from smoke intrusion, while the latter focuses on other parts of a building.

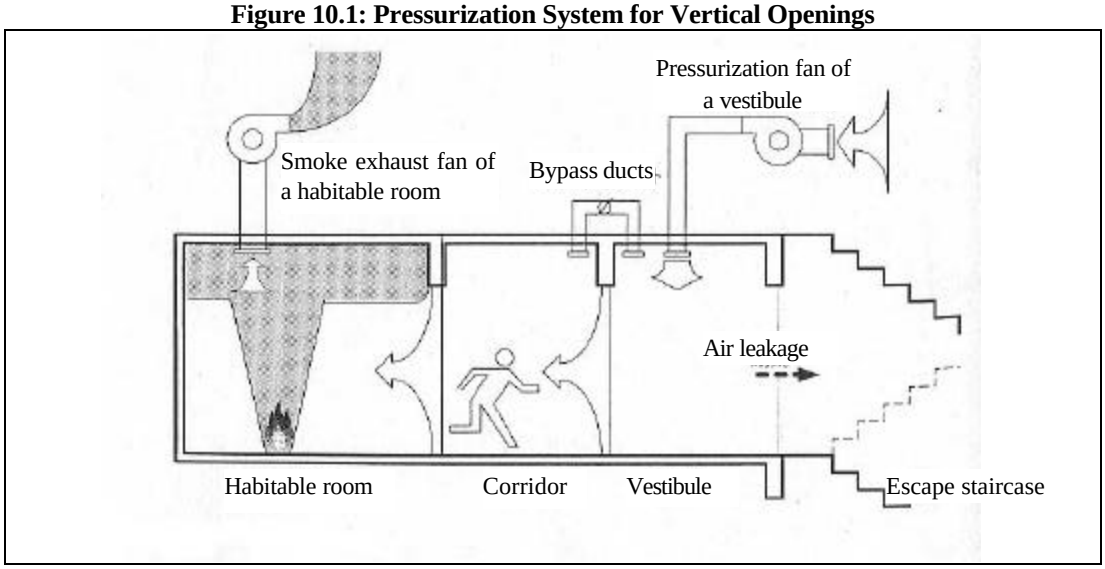
Moreover smoke separation of passive systems should be formed to secure reliability and performance of smoke control systems. The performance test is also needed for buildings with the pressurized systems.

Typical points of smoke control systems for vertical openings and large rooms are discussed in the following.

- Smoke control in vertical openings: Escape stairways and elevators for firefighters not only have important roles for evacuation and rescue activities but also can be a part of routes for smoke spread with high velocity. Therefore special measures should be executed for these parts. Escape staircases in high-rise buildings should be installed with vestibules where pressurization systems by mechanical air supply are equipped. This component is effective, because reliability for prevention of smoke intrusion is higher than pressurization systems in staircases. The number of doorways for the proposed component is smaller than pressurization in staircases, and this situation results in that influence to reduce air pressure by operation of doors also becomes smaller. In addition, required volume of air supply for pressurization is also reduced, as the areas for

pressurization is minimized.

Figure 10.1: Pressurization System for Vertical Openings



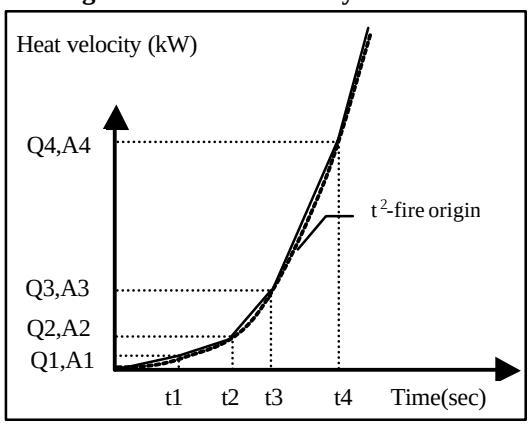
- Smoke control in large room: It is desirable that smoke control is designed so as be suitable for spatial conditions of a room of which combustible materials are clarified and floor area is large, such as atriums and gymnasiums. A simulation of smoke fluid progress is possible for these rooms. Upon the assumption that heat velocity of fire origin is grown up by a square of time (referred to the following formulas), volume of smoke generation is estimated taking into account volume of air swallowed up in processes of air rise. Two layers of smoke and air is formed in the room, and time for smoke descend and temperature of smoke is simulated.

  $Q=at^2$ (kW)

  $Af=Q/1,600$ (m^2)

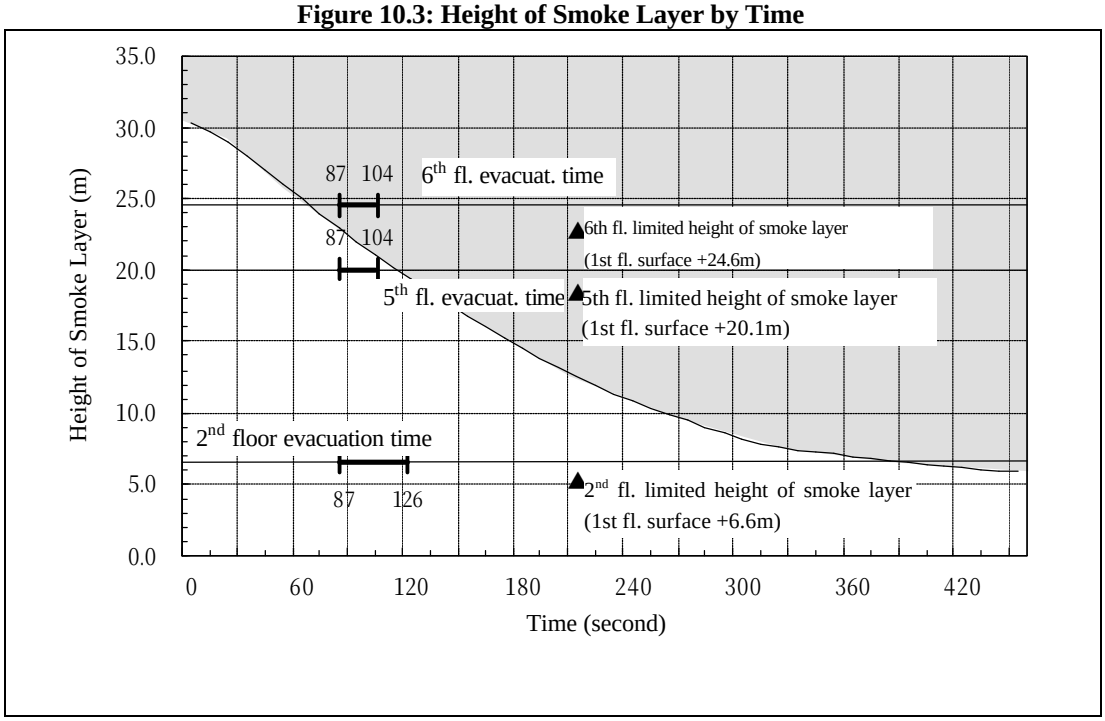
  (whereby, Q: heat velocity (kW), a: fire growth ratio (kW/s^2), t: time (sec), Af: horizontal area shadowed by a fire origin)

Figure 10.2: Heat Velocity and Time



Moreover, safety for evacuation is evaluated by checking required time for completion of evacuation which can be estimated by a number of occupants in the room and must be shorter than the time for descent of smoke layer to the level where occupants stay.

Figure 10.3: Height of Smoke Layer by Time



10.5 FIRE FIGHTING AND RESCUE

10.5.1 Access for Firefighters

The access for firefighters consists of three parts: open space for fire engines closely approached to a building, routes for entering into and moving within the building, and bases for fire fighting (life lobby for firefighters) and its command. In Thailand, MR 33 specifies an open space of 6m around high-rise and extra-large buildings. It also has requirements for elevators of firefighters and bases with 6 m^2 in floor area.

It is desirable that the building control act, further, specifies routes for entry into high-rise/large-scale buildings and fire fighting control rooms to systematically command fire fighting activities. In addition, it is recommended that requirements specify proper layout and routes between the entry into buildings, control rooms, elevators, and life lobbies.

10.5.2 Fire Fighting Equipment, etc.

i) Proper Requirement of Elevators for Firefighters

The MRs specify the use of 'elevators for firefighters' and 'life lobbies' around the elevator in high-rise and extra-large buildings. The elevator for firefighters needs to have defined quantity and technical standards. The fire code in Japan specifies one elevator for every 1,500m^2, two elevators for 4,500m^2, and an additional elevator by a further 3,000m^2 of floor area. It also specifies the dimension, velocity, and fire resistance of the elevator.

ii) Proper Installation of Fire Hydrant

Indoor fire hydrants are classified into two types. One is designed to be used by firefighters and the other one is provided for trained building users. The recommendation in this section focuses on the former one.

It is desirable to require indoor fire hydrants for buildings smaller that those excluded by MR 33 in conditions where public fire fighting facilities and urban water supply systems are well-prepared in the regions. The fire codes in Japan require indoor hydrants for buildings with a total floor area of more than 1,000 m^2 or any floors with 200 m^2 under the ground, without windows, or above the 4^{th} floor. The target scale of buildings in Japan is smaller than that in Thailand.

In addition, it is recommended that the amendment of ministerial regulation takes into account to introduce fire department hydrant and sprinkler system with hose connection, for efficient execution of fire fighting activities. The department hydrant aims to supply water by pump trucks through riser pipes installed in building structure and having dimension of several fire hoses. The sprinkler system with hose connection is a system to supply water from pump trucks to spray heads on underground floors. Upon the introduction of these fire extinguishing systems, current requirements for capacity of water resource of 30 minutes and the operation time of fire pumps in buildings should be coordinated with a time necessary for arrival and setting up of firefighters.

Table 10.18: Requirements of Indoor Fire Hydrant

Item	MR	BSL&FSL	IBC&IFC
General	1) 23m or more 2) 10,000m^2 or more	1) 1000m^2 or more 2) Basement floor, floor without window, and 4th floor or higher: 200m^2 or more	1) 9.14m higher or lower from an access of fire fighting: Class III-38mm diameter (for building users), and 64mm diameter (for firefighters) 2) A floor more than 929m$^{2/}$: 3) A part 60.96m far from an access for Class I (automatic and manual dry types)
Hotel	No specification by the classification of building	Refer to the general	Refer to the general
Office		Refer to the general	Refer to the general
Theater		1) 500m^2 or more in total floor area 2) Basement floor, floor without window, and 4th floor or higher: 100m^2 or more	Class I (automatic dry type): a part without sprinkler system and with 1,000 occupants or more (Excluding outdoor seats)
Hospital		1) 700m^2 or more in total floor area 2) Basement floor, floor without window, and 4th floor or higher: 150m^2 or more	Refer to the general
School			
Factory			
Multi-story Housing			
Dept. Store			
Alleviation		Alleviate the floor area: 1) Quasi-fireproof and noncombustible interior finish: 2 times 2) Fireproof and noncombustible interior finish: 3 times	Trade-off by installment of sprinkler systems
Layout	Distance between hydrants within 64m (Hose length: within 30m)	1) General: within 25m from any part of a building 2) Special: within 15m	1) Class I: a) 45.72m for staircase, landing, evacuation route without sprinkler system b) 60.96m for staircase, landing, evacuation route with sprinkler system 2) Class II: a) hose length (30.48m)+9.144m b) both ends of stage, atrium, and balcony for theater 3) Class III: Same with Class I and II
Water Volume	Water for 30-minutes supply	General: 1.2m^3/hydrant (max. two sets) (in case alleviation: 2.6m^3)	-
Performance	1) At the highest floor: 0.45 - 0.7MP 2) 30l/s or more for the first hydrant, and 15l/s for the second 3) 95l/s in total	1) General: water pressure - 0.25MP, and sprayed volume - 60l/minute 2) Alleviated case: water pressure - 0.17MP and sprayed volume - 130l/minute	-
Alternative	No specification	By installment of: 1) Sprinkler, 2) Spray sprinkler, 3) Form sprinkler, 4) Carbon dioxide sprinkler, 5) Powder sprinkler, or 6) Fire pump.	-

Source: JICA Study Team

Table 10.19: Requirements for Outdoor Fire Hydrant and Fire Department Hydrant

Item		MR	BSL&FSL	IBC&IFC
Outdoor Fire Hydrant	Target Building	1) 23m or higher 2) 10,000m^2 or more	1) Fireproof building: 1story and 2stories building with 9,000m^2 or more 2) Quasi- fireproof building: 1story and 2stories building with 6,000m^2 or more 3) Other: 1story and 2stories building with 3,000m^2 or more	-
	Layout	Specified	Within 40m from any part of a building	-
	Volume of Water	No specification	No. of hydrants x7m^3 (Max. No. of hydrants is 2 sets.)	-
	Performance	Specified	1) Water pressure of sprayed water: 0.25MP or more 2) Volume of sprayed water: 350l/minute	-
	Trade-off	No specification	By installment of: 1) Sprinkler, 2) Spray sprinkler, 3) Form sprinkler, 4) Carbon dioxide sprinkler, 5) Powder sprinkler, or 6) Fire pump.	-
Fire Department Hydrant	Target Building	No specification	1) 7th floor or higher 2) 5th floor or higher and 6000m^2 or more in total floor area	-
	Layout of Hose	No specification	3rd floor or higher: within 50m from any part of a building (A part adjacent to staircase and elevator for firefighters is recommendable for efficient fire fighting.)	-

Source: JICA Study Team

iii) Fire Fighting Control Room

It is of significant issue how efficiently fire fighting and rescue activities can be carried out in extra-large buildings with a floor area of more than 10,000m^2 and in high-rise buildings of more than 7 stories. To solve this issue, the provision of a fire fighting control room is indispensable. In the fire codes in Japan, there is no requirement for a fire fighting control room, but it is recommended in the course of the technical assessment. In the USA, a control room is required for any high-rise building of more than 22.86m height.

It is recommended to prepare the provision for a fire fighting control room for buildings of a certain scale in Thailand. Reflecting various situation of buildings, the requirements should be legislated for proper design of the room by specifying, for example, availability for daily use and installment of room for each building use of complex buildings that have complicated administration systems.

The role of the fire fighting control room should be responded to conditions of buildings. It includes central administration and security in the daily use, and monitoring a fire outbreak, instruction for preventing fire outbreak, and a base for fire fighting activities in emergency cases. The fire fighting control room should be protected by both fire and smoke separations. The materials inside should be

noncombustible. In addition, the fire fighting control room requires easy accesses from the outside of a building and within the building.

10.6 PREVENTION OF BUILDING COLLAPSE

Article 24 of MR 48 stipulates fire resistance of the principle structure and Article 23 of MR 48 requires fire resistance for a principle structure for buildings over three-stories. These articles need improvements with regard to the following points.

i) Expansion of Target Parts

The current act defines the principle structure as columns, beams, floors, and joists. It is desirable that the target parts of principle structure include walls and roofs to cover any part of buildings that resist to structural load.

ii) Expansion of Target Buildings

The current requirements aim to prevent building collapse of a large buildings over a three-story height or over 1,000m^2 in total floor area and special buildings which include warehouses, condominiums, theaters, hotels, and hospitals without any definition of scale of buildings. It is desirable for relieving excessive requirements that the target buildings are defined with building uses and scale of buildings, such as floor areas and number of floors.

iii) Proper Fire-resistant Rating

Similar to high-rise and extra-large buildings, the MR specifies a fire resistant rating of 3-hours for column and beams, and 2-hours for floors for one-story buildings and other small scale buildings. This requirement is excessive, since a building with small scale and easy evacuation does not require such a high rating. Therefore a lower rating could be applied and a reasonable fire safety level.

In addition, it is required to set the fire-resistant rating by building part such as columns, beams, floors, walls, and roofs in accordance with classification of buildings by the building use, type of structure, number of floors, and floor area. It is expected to allow some latitude by scale of target building such as one to three hours for columns, beams, and walls, and one to two hours for floors and roofs.

iv) Evaluation of Fire-resistance Rating

Fire-resistance performance of structures, elements, and equipment of buildings should be evaluated reaction of these parts in heating temperature in conformity with the standard time-temperature curve of ISO834. It is desirable that evaluation criteria for fire-resistance include the structural stability, temperature increase at unheated side of specimens, and temperature increase of steel materials.

v) Specification Based Code

Ministerial Regulation No. 48 details the specification for fire resistance of structure by the minimum thickness of the covering of reinforced concrete and the fireproof covering on steel frames. As it is more preferable for these items to be specified in the EIT standard, an adjustment between the MR and the standard is necessary.

Table 10.20: Type of Construction by Scale of a Building (MR and EIT)

Classification of Building	MR (Min. scale of fireproof building)	EIT (Max. limitation by construction)					
		Type I		Type II		Type III	
		UL	L	1Hour	UL	1Hour	UL
(Height)	-	UL	48	20	17	15	12
Hotel	1 story or higher	NA UL	12 2700	4 1200	2 800	3 900	2 500
Office	3 stories and 1000m^2 more	NA UL	12 3600	4 1600	2 1100	3 1300	2 700
Theater	1 story or higher	NA UL	4 2700	NA NA	NA NA	NA NA	NA NA
Hospital		NA UL	2 4100	NA NA	NA NA	NA NA	NA NA
School	3 stories and 1000m^2 more	NA UL	4 4100	2 1800	1 1200	2 1400	1 800
Factory		NA UL	12 3600	4 1600	2 1100	3 1300	2 700
Multi-story Housing	1 story or higher	NA UL	3 UL	3 UL	3 UL	3 UL	3 UL
Dept. Store	3 stories and 1000m^2 more						

Note: 1) Values of EIT: Upper row - max. number of floors, Lower row - max. floor area
2) Hatched value: fire-resistant rating is required.

Table 10.21: Type of Construction by Scale of a Building (BSL and IBC)

Classification of Building	BSL (Min. scale of fireproof and quasi-fireproof building)		IBC (Max. limitation by construction)								
	Fireproof Building	Quasi-fireproof Building	Type I		Type II		Type III		Type IV	Type V	
			A	B	A	B	A	B	HT	A	B
(Height)	-	-	UL	49	20	17	20	17	20	15	12
Hotel	3 stories or more	300m^2 in 2nd floor or more	UL UL	11 UL	4 2230	4 1486	4 2230	4 1486	4 1905	3 1115	2 650
Office	-	-	UL UL	11 UL	5 3484	4 2137	5 2648	4 1765	5 3344	3 1672	2 836
Theater	3 stories or stage of 200m^2 or more	-	UL UL	5 UL	3 1440	2 790	3 1301	2 790	3 1394	2 1068	1 511
Hospital	3 stories or more	300m^2 in 2nd floor or more	UL UL	9 5110	4 1765	3 929	4 1533	3 929	4 1672	3 975	2 418
School	3 stories or more	2000 m^2 or more	UL UL	5 UL	3 2462	2 1347	3 2183	2 1347	3 2369	1 1719	1 883
Factory	3 stories or more	150 m^2 or more	UL UL	11 UL	5 3484	3 2137	4 2648	3 1672	5 4692	3 1951	2 1208
Multi-story Housing	3 stories or more	300m^2 in 2nd floor or more	UL UL	11 UL	4 2230	4 1486	4 2230	4 1486	4 1905	3 1115	2 650
Dept. Store	3 stories or 3000m^2 or more	500m^2 or more	UL UL	11 UL	4 1997	4 1161	4 1719	4 1161	4 1905	3 1301	1 836

Note: 1) Values of IBC: Upper row - max. number of floors, Lower row - max. floor area
2) Definition of construction in IBC: Type I and Type II - noncombustible materials, Type III - fire resistance at external walls (wooden frame construction is acceptable.), Type IV - fire resistance at external walls (wooden frame construction is acceptable.), and heavy timber, Type V - no requirement.
3) Hatched value: fire-resistant rating is required.

Table 10.22: Fire-resistant Rating in the MRs, EIT Standard, BSL, and IBC

Part	MR	EIT						BSL				IBC(601)								
		Type 1		Type 2		Type 3		Fireproof			Quasi-f	Type I		Type II		Type III		Type IV	Type V	
		UL	L	1 hour	UL	1 hour	UL	4th fl. from the top floor	5-14th fl. from the top floor	15th fl. or more fl. from the top floor	ireproof	A	B	A*1	B	A*1	B	HT	A*1	B
Column and Beam	3	3	2	1	-	1	-	1	2	3	0,75	3	2	1	0	1	0	HT	1	0
(Support for roof floor)	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Structural Wall																				
1) External	-	4	4	1	-	1	-	1	2	2	0,75	3	2	1	0	2	2	2	1	0
2) Partition	-	3	2	1	-	1	-	1	2	2	0,75	3	2	1	0	1	0	1/HT	1	0
(Support for roof floor)	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-
Floor	2	2	2	1	-	1	-	1	2	2	0,75	2	2	1	0	1	0	HT	1	0
Roof	-	2	1	1	-	1	-	0,5			0,5	1,5	1	-	-	-	-	-	-	-
(Escape floor)	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-
Staircase	-	2	2	1	1	1	1	0,5			0,5	-	-	-	-	-	-	-	-	-

Source: JICA Study Team
Note: HT - Heavy Timber

Table 10.23: Fire Testing Standards

Item		ISO834	Japan	ASTM E 119	BS 476	Thailand
Specimen	Wall	3x3m or more (height by width)	3mx3m or more (height by width)	$9m^2$ or more 2.7m/side or more	3mx3m or more (height by width)	MR: ASTM E 119 EIT: ASTM E 119 and BS476
	Floor/Roof	4x3m ore more (2 sides support) 4x2m or more (4 sides support) (span by width)	4x3m or more (length by width	$16m^2$ or more 3.7m/side or more	4x3m or more (span by width)	
	Column	3m or more (height)	No specification	2.7m or more (height)	3m or more (height)	
	Beam	4m or more (span)	4m or more (length)	3.7m or more (length)	4m or more (span)	
	Stair	-	1.2m (width) x 5 steps or more	-	-	
Heating Method	Heat Temperature	Standard time-temperature curve: T-To=345log10(8t+1) (T: Temperature at current time: t, To: Temperature before heating, t: time of heating)		Original time-temperature curve	Standard time-temperature curve	
	Heated Side	Column: All sides Wall: One side	Wall: One side Floor and Roof: below side Beam: Three sides except above Stairway: All sides that may be heated in case of fire.	Column: All sides Floor, wall, and roof: One side	Column: All sides Beam: 3 sides Wall: One side Floor and roof: Below side	
	Monitoring Period	Until crack occurs.	1)Time of heating: Required fire-resistant rating 2)Time after the heating: 3 times of required fire-resistant rating	Required fire-resistant rating	Until crack occurs.	
Evaluation Criteria	Loading Factor	Allowable design load	Structure having vertical load in normal condition: Loading to cause stress on the structure at the same level of the long term stress	Allowable design load	Allowable design load	
	Structural Stability	National fire code is permitted.	1)Floor, roof, and beam a) Max. bending: $L^2/400d$ or less (mm) b) Max. bending velocity: $L^2/9000d$ or less(mm/minute) (span: L (mm)、 d: distance between top edge and the bottom of tension area in a section of structure (mm)) 2)Wall a) Max. axis compression: h/100or less (mm) b)Max. axis compression velocity: 3h/1000 or less (mm/minute) (Original height: h (mm))	1)Capable to support the testing load 2)Temperature of steel is lower than: a) 704 in max. and 593 in avg. for steel, b)593 in avg. for RC, and c)427 in avg. for PC.	1)Horizontal membrane: a) Max. bending: L/20 or less (mm) b) Max. bending velocity: $L^2/9000d$ or less (mm/minute) 2)Vertical membrane: Capable to support the testing load.	
	Flame Resistance	1)No ignition of cotton pad 2) No flame breaks out to the unheated side for 10seconds.	No occurrence of phenomenon during 1-hour heating for wall and floor, 0.5-hour heating for roof, as listed below. 1) No crack permissible for flame spread 2) No flame to the unheated side for 10 seconds 3) No flame on the unheated side for 10 seconds	No ignition of cotton pad	1)No flame to the unheated side for 10 seconds 2)No occurrence of gaps permitting: a) 6 mm gap gauge can move along a gap more than 150mm. b) 25 mm gap gauge can penetrate the structure.	
	Heat Resistant	Temperature of unheated side less than: a)Average: 140+ initial temp. b)Max: 180+ initial temp. c)Max: 220	For wall and floor, the temperature of unheated side during 1-hour heading less than: a)Max.: 180+ initial temperature b) Avg.: 140+ initial temperature	Avg. temperature of unheated side (wall, floor, and roof): less than 139+initial temperature	Temperature of unheated side less than: a)Avg.: 140+initial temperature b)Max: 180+ initial temperature	

Source: JICA Study Team

10.7 CLASSIFICATION AND DEFINITION OF A BUILDING

In order to specify the measures for fire prevention of a building by the act and the standard, the measures should be in accordance with building use, height (the number of floors), scale (floor area). In the present act of Thailand, the definition of a building scale is specified for three types, Tall Building and Large Building, and Extra-large Building, based on building height and floor area. Public Building (assembly building), Special Building, and three kinds of building scale are taken into consideration as buildings, which require special consideration for secure fire safety. Other then those classifications, thirteen types of independent use are defined at present. Among those, seven uses in detail for housing use have been defined, but there is only a rough classification for other uses. For example, medical facility and education are bundled together with Public Buildings. The definition of hotels relies on that of the relevant law for hotels.

Medical facilities are used for many persons weak to disasters while a hotel was the site of one of the two major building fires in Thailand. In the building control act, a single classification type should be conferred upon medical facilities and hotels, respectively, and it is expected to be able to specify a fire prevention system suitable for each use.

It is important to consider the following composition, which conforms to the basic 11 kinds of building uses defined by the EIT standard for the improvement of stipulation.

i) Thirteen building uses except the warehouse of ministerial regulations shall be regrouped into six kinds: Assembly, Business, Commercial, Industrial Factory, Miscellaneous, and Residential.

ii) Additional building uses to the revised ministerial regulations shall be five kinds: Education, Social Welfare, Danger Hazardous, Service Center, and Health Hazardous. The amendment shall clarify the definition of service center for which the EIT standard specifies only its name.

iii) Warehouse, that is not specified in the EIT standard, is covered by 11 building uses mentioned above by classification of things stocked in the warehouse. The total number of basic building uses in the ministerial regulations and the EIT standard will be 11 kinds.

Table 10.24: Classification of Building in the Building Standard Law (JPN) and the International Building Code (US)

BSL (JPN)	IBC (US)		
Theater, Movie Theater, Entertainment halls, Grand-stands, Public halls、Assembly halls	Assembly	Gathering together of persons for purposes.	
	A-1	Production and viewing of the performing arts or motion pictures	Motion picture theaters, Theaters
	A-2	Food and/or drink consumption	Banquet halls, Night clubs, Restaurants, bar
Hospitals, Hotels/inns, Apartment houses, Boarding houses	A-3	Worship, recreation or amusement	Art galleries, Churches, Libraries, Gymnasiums
	A-4	Viewing of indoor sporting events	Arenas, Skating rinks, Tennis courts
	A-5	Participation in or viewing outdoor activities	Amusement park, Grandstands, Stadiums
Schools, Gymnasiums	Business	Office, professional or service transactions	Banks, Civic administration, Clinic-outpatient, Educational occupancies above the 12th grade
Department stores, Markets, Exhibition halls, Cabarets, Dance halls	Educational	By six or more persons at any one time for educational purposes through the 12th grade.	
	Factory Industrial	Assembling, disassembling, fabricating, finishing, manufacturing, packaging, or repair operations	
Warehouses	F-1	Moderate Hazard	Automobiles, Electronics, Food processing, Furniture, Machinery, Metal
Automobile garages, Automobile repair shops	F-2	Low Hazard	Beverages (nonalcoholic), Brick and masonry, Ceramic products, Foundries, Glass products
	Hazardous	Manufacturing, processing, or storage of materials with a health hazard in quantities.	
	H-1	Materials posing a detonation hazard	Explosives, Organic peroxides, unclassified detonable, Oxidizers
	H-2	Materials posing a deflagration hazard or a hazard from accelerated burning	Combustible dusts, Cryogenic liquids, flammable, Flammable gases
	H-3	Materials readily supporting combustion or posing a physical hazard	Aerosols, Combustible fibers, Consumer fireworks, Cryogenic liquids, oxidizing
	H-4	Materials that are health hazards	Corrosives, Highly toxic materials
	H-5	Semiconductor fabrication facilities and comparable research and development areas	
	Institutional	People having physical limitations	
	I-1	Housing more than 16 persons without physical assistance for emergency	Care facilities, Social rehabilitation facilities
	I-2	Medical care of more than 5 persons, not capable of self-preservation.	Hospitals, Nursing homes, Mental hospitals
	I-3	Inhabited by more than 5 persons under restraint or security	Prisons, Jails, Reformatories
	I-4	Custodial care by individuals other than parents, and in a place other than the home.	
	Mercantile	Display and sale of merchandise	Department stores, Markets, Sales rooms
	Residential	Sleeping accommodations	
	R-1	Transient occupants	Boarding houses, Hotels
	R-2	More than two dwelling units for permanent occupants	Apartment houses, Dormitories
	R-3	More than two dwelling units or adult and child care facilities, that provide accommodations for five or fewer persons of any.	
	R-4	Residential Care/Assisted Living Facilities including 5～16 occupants, excluding staff.	
	Storage		
	S-1	Moderate-hazard storage	Aerosols, Aircraft hangar, Bags, Bamboo
	S-2	Low-hazard storage	Asbestos, Cement in bags, Electrical coils
	Miscellaneous	Accessory characters and miscellaneous structures	Agricultural buildings, Carports, Fences more than 6 feet high, Retaining walls, Tanks

Table 10.25: Classification of Building in the Building Act (ENG) and the Building Code of Australia

Building Act (UK)			Australian Building Code (AUS)		
Residential (dwellings)	1(A)	Flat or maisonette	1	One or more buildings constituting-	
	1(B)	Dwelling house which contain a habitable story with a floor level more than 4.5m above ground level.	1a	Single dwelling being i) a detached house, ii) one or more attached dwellings, a row house, terrace house, town house, or villa unit	
	1(C)	Dwelling house which does not contain a habitable story with a floor level more than 4.5m above ground level.	1b	Boarding house, guest house, hostel with a total floor area not exceeding 300m2 and not more than 12persons	
	Note	surgeries, consulting rooms, office or other accommodation, not exceeding 50m2 in total, forming part of a dwelling and used by an occupant of the dwelling	2	Building containing 2 or more sole occupancy units being a separate dwelling	
institutional	2(A)	Hospital, home, school used as living accommodation where such persons sleep on the premises.	3	Residential building which is a common place of long term or transient living for a number of unrelated persons - Boarding houses, guest houses, hostels, lodging houses or backpackers accommodations - Residential part of hotels or motels - Residential part of schools - Accommodation for the aged, disabled or children - Residential part of a health-care with staff - Residential part of detention centers	
other	2(B)	Hotel, boarding house, residential college, hall of residence, hostel, and any other residential purpose, not described above			
Office	3	Offices or premises used for the purpose of administration, clerical, handling money, and communications, etc.	4	Dwelling in a building that is Class 5, 6, 7, 8 or 9 if it is the only dwelling in the building	
			5	Office building used for professional or commercial purpose	
Shop and Commercial	4	Shops or premises used for a retail trade or business, and premised to which the public is invited to deliver or collect goods in connection with their hire repair or other treatment, etc.	6	Shop or other building for the sale of goods by retail or the supply of serviced direct to the public	- eating room, café, restaurant, milk or soft-drink bar - dining room, bar shop, or kiosk part of a hotel or motel - hairdresser's or barber's shop, public laundry or under taker's establishment - market of sale room, showroom, service station
Assembly and Recreation	5	Place of assembly, entertainment, or recreation; including bingo halls, conference, exhibition and leisure centers, swimming pool buildings, skating rinks, churches, etc.	7	Building which is	- carpark - for storage or display of goods or produce for sale by wholesale
Industrial	6	Factories and other premises used for manufacturing, altering, repairing, cleaning, washing, breaking-up, etc.	9	Building of a public nature-	
			9a	Heath-care building	
			9b	Assembly building including trade workshop, laboratory, primary or secondary school	
Storage and other non-residential	7(A)	Place for the storage or deposit of goods or materials (other than described under 7(B))			
	7(B)	Car parks designed to admit and accommodate only cars, motorcycles and passenger or light goods vehicles weighing no more than 2,500kg gross.	10	Non-habitable building or structure	
			10a	Private garage, carport, shed	
			10b	Fence, mast, antenna, retaining or free-standing wall, swimming pool	
	Note	A detached garage not more than 40m2 in area is included in purpose group 1(C), as is a detached open carport of not more than 40m2, or a detached building.	A3.3	Multiple Classification	Each part of a building must be classified separately or applying the major use to the whole story
			A3.4	Parts with more than one classification	

CHAPTER ELEVEN:
IMPROVEMENT OF EXISTING BUILDINGS

11.1 OUTLINE OF EXISTING SYSTEM

Also in Thailand, it is impossible to retroactively apply the new regulations to the existing buildings. Therefore, it will be fundamental to ask for the improvements to be added, one by one, during any future extension or alteration of the buildings. However, there are many high-rise and large scale buildings having a high fire hazard. These must be improved without waiting for any extension and alteration work to the building.

From such a viewpoint, it is significant to prepare a regulation that is like MR 47, but focused on the improvement of the existing unsafe buildings. Regulation MR 47 requires the improvement of fire safety for existing buildings including high-rise and large-scale, extra-large, public buildings, multi-story housing, factories, restaurants, and offices. It specifies the improvement of six items as listed below.

i) Installment of an additional stairway other than the main stairways for a building with 4 stories or more. The additional stairway is enclosed by noncombustible material and has a smoke-proof fire door that has an automatic closing device, with a size more than 80 cm in width and 2 m in height.

ii) Installation of a layout plan showing habitable rooms, portable fire extinguishers, doors, evacuation routes, etc. in the first floor and in front of each elevator at each floor.

iii) Installation of a portable fire extinguisher for every 1,000 m^2, within an interval of 45 m, at least one piece per floor, and within 1.5 m in height.

iv) Installation of a fire alarm at each floor. The alarm should be a signal or sound type with automatic and manual devices.

v) Installation of EXIT signs and emergency lighting on both sides of doors on evacuation routes.

vi) Installation of lightning protection.

These stipulations were prepared to be implemented without any major change of the structure and equipment of existing buildings. They were finally narrowed down to six items from nine items originally drawn up in the course of legislation of the MR. Therefore, the effect of requirement may be limited even if the improvement of building is advanced in accordance with the requirement of ministerial regulation.

11.2 APPROACH TO THE IMPROVEMENT OF EXISTING BUILDING

Part I described what is necessary for promoting the improvement of the existing building by a combination of inspection of a building in use, the grading of safety, and the financial preferential measure, etc. Here, the requirement for improvement on fire safety of the existing buildings is described.

(1) Target Buildings

It will be difficult to treat all existing buildings similarly by ordering through improvement and administrative control, but it is possible to ask for improvement gradually after determining what has high urgency. To achieve this, it is necessary to establish rational and clear regulations to which it is easy to obtain a public understanding. It is important to be able to apply a strong order by the building administration for a building having a high hazard, while a reprieve period should be given for small scale buildings where the possibility of fire accident is low.

The followings present the criteria for setting up the priorities.

1) High-rise/large/extra-large buildings built before the enforcement of the MR 33,
2) High-rise/large/extra-large buildings built after the enforcement of the MR 33,
3) Building other than high rise/large/extra-large buildings but having facilities for sleeping and disabled occupants,
4) Building other than high rise/large/extra-large buildings but used by many and unspecified occupants.

Among these buildings, the ones which have the lowest grade, of the three grades in terms of safety by the new ministerial regulation, should be targeted.

(2) Measures to be introduced

As mentioned in Part I, imposing a duty of improvement to a building in use will bring a large financial burden for the operators of a building. Therefore, the improvement should limited to the most important part of fire preventive technologies. An evaluation axis to extract the technologies for existing buildings among the fire protection system is noted below.

- Indispensable measure from a viewpoint of life safety (safe evacuation), and
- Measure which does not require large investment (not accompanied by installment of a large-scale equipment), and
- Measure to complete construction within the short period and keep short the discontinuation period for profit by building use.

Comparing with such an evaluation axis, the following measures are recommended for introduction.

- Provision of evacuation routes with safe and sufficient capacity is indispensable for improvement of existing buildings.

On the other hand, if uniform requirements are applied to existing buildings, some of buildings may be impossible to comply with the requirements due to structural limitations. For example there is no sufficient space for a new escape stairway in existing buildings. Therefore, the flexible requirements with alternative measures are necessary rather than the uniform requirements to select proper improvement measures for buildings as the fire codes in Japan and USA adopt. The requirements shall principally aim to secure the life safety (evacuation safety). In this circumstance, it is recommended that every improvement measure for fire protection is set with numerical points which is summed up for comprehensive evaluation of fire safety of a building. The evaluation of fire safety should be adjusted with the grading of buildings which will be specified in a new MR.

11.3 RECOMMENDATION OF AMENDMENT ON THE MINISTERIAL REGULATIONS

In the light of the above evaluation axis, the items with a high need of improvement are summarized below.

(1) Securing of Evacuation Safety

What needs to be rectified the most to ensure safe evacuation in an existing building is any part of an evacuation route or escape stairway that does not currently have any provision of smoke control and fire resistance. This should also encompass the outside escape stairway which is practically out of use for evacuation.

In order to improve these routes, it is important to lay out evacuation routes with capacity evacuation with capacity corresponding to the floor area and the number of occupants. These evacuation routes should be capable for completion of evacuation within an appropriate time and protected from fire and smoke with fire preventive measures at openings in the evacuation routes.

In case where a existing building are not able to have adequate evacuation route, the requirements should include alternatives options for safety and redundancy of evacuation that can be retrofitted into existing building layout. The alternatives options would include 1) balcony linking, 2) use of evacuation equipment, and 3) horizontal exits.

Furthermore the facilities for the smooth evacuation requires the following fire prevention systems to the fullest extent possible.

i) Installation of the detection system in the rooms where the high possibility of fire outbreak occurs, etc. and the use of alarm and public address

equipment to all parts of building.

ii) Installment of emergency lighting and exit sign illumination, and

iii) Installment of doors with locking methods which allows these doors to open in the evacuation direction without any key or special device.

(2) Introduction of Vertical Opening Protection

It is indispensable that fire spread is confined within a certain number of floors to secure required time for evacuation. This may be achieved by the forming vertical opening protection at shafts, stairways, and elevator shafts, as most of floors are made of a fire resistant material in Thailand. The vertical opening protection is useful for confining a fire within the certain number of floors and securing safety of escape stairways.

(3) Inducement of Alternative Measures

The improvement options for building fire safety should include following alternatives.

i) Preventing initial fire development and fire spread as much as possible. Partition walls are generally made with noncombustible materials in Thailand. Therefore it is effective that use of noncombustible materials in openings and penetrated parts of partition walls to form fire separation, especially at areas that have the large amount of noncombustible materials and occupants.

ii) Installation of an emergency entrance for firefighters. In the case of a high-rise building, clear indication of routes and pre-applications to the Fire Department is required.

iii) Establishment of 24-hours management system for securing the efficient action in case of fire,

iv) Periodically carrying out fire drills for securing evacuation safety in an outbreak of fire. They aim to secure safety of building users.

11.4 CASE STUDY FOR IMPROVEMENT OF EXISTING AND NEWLY CONSTRUCTED BUILDINGS

11.4.1 Methodology of the Case Study

Among the 125 existing buildings subjected for the questionnaire survey, six buildings have been selected for a case study that aims to estimate construction cost and damaged floor area before and after improvement of fire protection systems. The case study buildings were selected to cover six building uses among target building

uses of the Study, namely hotel, hospital, complex, multi-story housing, factory, and shop-house.

The former three uses are kinds that have large permitted floor areas per building during the last nine years, according to the statistics of the National Statistical Office (NSO). In the case study, these uses are treated as types of which large-scale buildings will be constructed in the future. In practice, plans of three buildings are once modified to the level conformable to all requirements of existing ministerial regulations. Then the modified plan is treated as that of newly constructed buildings and improved to the requirements of the Building Standard Law in Japan with estimation of additional construction cost and damaged floor.

On the other hand, the latter three building uses of multi-story housing, factory, and shop-house focus on the buildings that have rather small capital. These buildings are treated as existing buildings and estimation is examined for improvements from existing condition to a level of the ministerial regulations of Thailand and to the Building Standard Law in Japan.

11.4.2 Results of the Case Study

Improvement cost for the new buildings has been estimated at 1.8 to 3.6% of unit construction costs (Baht/m^2). In details, improvement for passive systems need increase of 1.2 to 1.6%, while increase for active systems are estimated at 0.7 to 2.0%.

Table 11.1: Improvement Cost of New Buildings

Classification		Construction Cost			Damaged Floor Area (m^2)	
		Original (Baht/m^2)	Increase by Improve. (Baht/m^2)	Increase Ratio (%)	Before Improvement	After Improvement
Hotel	Passive System	-	580	1.2	-	-
	Active System	-	368	0.7	-	-
	Total	50,000	948	1.9	166	32
Hospital	Passive System	-	211	0.6	-	-
	Active System	-	419	1.2	-	-
	Total	35,000	630	1.8	2,641	950
Complex	Passive System	-	564	1.6	-	-
	Active System	-	707	2.0	-	-
	Total	35,000	1,271	3.6	949	53

Source: JICA Study Team

Note: 1) Original construction cost is assumed cost to comply with the existing ministerial regulations.
2) Improvement cost is estimated amount for improvement of fire protection system to comply with the Building Standard Law in Japan.

On the other hand, additional cost for the improvement of the existing buildings to comply with the Building Standard Law in Japan has been estimated to 1.9 to 3.9% of unit construction cost (Baht/m^2). Improvement of the passive system needs additional cost of 0.2 to 1.8% to the unit cost. The active system improvement demands 1.6 to 2.0%.

Table 11.2: Improvement Cost of Existing Buildings

Classification		Construction Cost					Damaged Floor Area (m^2)		
		Original	Increase to MR		Increase to BSL		Original	Improve to MR	Improve to BSL
		(Baht/m^2)	(Baht/m^2)	Ratio (%)	(Baht/m^2)	Ratio (%)			
Multi-story Housing	Passive	-	32	0.1	85	0.3	-	-	-
	Active	-	148	0.6	395	1.6	-	-	-
	Total	25,000	180	1.9	480	1.9	553	307	60
Factory	Passive	-	14	0.1	37	1.8		-	-
	Active	-	146	0.7	390	2.0	-	-	-
	Total	20,000	160	0.8	427	3.9	1,436	798	288
Shop-house	Passive	-	138	0.7	368	1.8	-	-	-
	Active	-	152	0.8	406	2.0	-	-	-
	Total	20,000	290	1.5	774	3.9	11,074	6,152	349

Source: JICA Study Team

Note: 1) Original construction cost is assumed cost for existing conditions.
2) Increased cost to MR is estimated amount for improvement of fire protection system to comply with the existing ministerial regulations.
3) Increased cost to BSL is estimated amount for improvement of fire protection system to comply with the Building Standard Law in Japan, including cost for improvement to the ministerial regulation level.

The case study has figured out increase of construction cost for improvement of new and existing buildings as a few percents to unit construction cost. It should be noted that every building has its own unique characteristics of spatial layout and use of building as well as fire protection systems. Therefore, the result of the case study should be treated as a yardstick in particular situation which is not adequate to apply for other buildings.

CHAPTER TWELVE: RECOMMENDATION OF AMENDMENT OF MINISTERIAL REGULATIONS BY ARTICLE

12.1 POINTS OF RECOMMENDATIONS

Based on the recommendations discussed in the Chapter 10 and Chapter 11, main points of amendments by each article of existing ministerial regulations are examined in the following sections. These points cover necessary coordination and preparation of the EIT standards and ASA standards to establish systematic fire codes in Thailand.

12.2 MINISTERIAL REGULATIONS NO. 33 AND NO. 50

Points for the amendment of MR 33 and MR 55 are discussed below.

(1) Article 1

MR: Modify the classification of building uses to be same with the definition of EIT standard.

EIT Stds: Supplement a definition of Social Center of which contents of definition is not currently specified.

ASA Stds: Specify classification of building uses as same as MR and EIT standards.

(2) Article 14

MR: Devolve specification for minimum time of emergency power supply.

EIT Stds: Specify minimum time of emergency power supply by each fire protection equipment.

(3) Article 16

MR: Specify individual definitions for detection systems and alarm/report systems.

EIT Stds: Specify installment standards of each type of detectors and alarm/reporting equipment. The type of detectors should include heat, fire, and smoke detectors as well as gas leakage detectors, while alarming equipment include public address systems.

(4) Article 18

MR: Devolve specification of fire hydrants to EIT standards.

EIT Stds: Specify installment standards of fire hydrants, corresponding to the preparedness of fire fighting facilities and infrastructure.

(5) Article 20

MR: Devolve installment standards for sprinkler systems.

EIT Stds: Specify installment standards for sprinkler systems, corresponding to the preparedness of fire fighting equipment and infrastructure by each region.

(6) Article 22

MR: Specify definition of evacuation routes consisting of exit accesses, exits, and exit discharges.

ASA Stds: Stipulate specification of three parts of evacuation routes and basic conditions, such as continuity, ease of travel, ease of understanding, etc.

MR: Specify the necessity of adequate number of evacuation routes, corresponding to the number of occupants.

ASA Stds: Specify required number of evacuation routes.

MR: Specify the maximum exit access travel distance and maximum length of common pat of exit access.

ASA Stds: Specify distances mentioned-above by each building use.

MR: Devolve estimation method of evacuation time.

ASA Stds: Specify a method for evacuation time, together with alternative measures to secure evacuation time, such as horizontal exits, safe separation, confined horizontal exits, and balcony linking.

(7) Article 23

MR: Specify handrails at both sides of stairways.

(8) Article 24

MR: Specify the necessity of fire protection at openings within a certain distance around outside escape stairways.

ASA Stds: Specify fire-resistance rating and applicable measures.

(9) Article 25

MR: Specify the necessity of smoke-proof staircases for high-rise buildings with a certain number of floors.

ASA Stds: Specify installment standards of smoke-proof staircases.

MR: Specify balconies and vestibules with smoke exhaust systems for smoke-proof staircases.

EIT Stds: Specify installment standards of pressurized smoke control.

MR: Specify performance test and verification method of the pressurized smoke control system.

EIT Stds: Specify the verification method and standards for performance test.

(10) Article 26

MR: Specify the necessity of exit signs/exit sign illumination and emergency lighting in the entire evacuation routes. Devolve specifications for exit signs and emergency lighting to the EIT standards.

EIT Stds: Specify installment standards of exit signs/exit sign illumination and emergency lighting.

MR: Devolve the specification of evacuation facilities.

EIT Stds: Specify fire-resistance rating and applicable measures which should cover fire protective measures at openings of evacuation facilities.

(11) Article 27

MR: Specify the necessity of adequate width of evacuation routes, corresponding to the number of occupants.

ASA Stds: Specify the required width of escape routes.

(12) Article 28

MR: Devolve specifications of elevators for firefighters, corresponding to the floor area.

EIT Stds: Specify the installment standards for the elevators, including required number of elevators, their dimension, velocity, etc..

(13) New Article

MR: Specify the definition of hazardous materials and the necessity of their fire preventive measures. The definition should be coordinated with related laws.

EIT and ASA Stds: Specify type of hazardous materials with their allowable limitation in quantity. Specify the safe measure for materials more than specified quantity.

MR: Specify the use of noncombustible interior finish in the entire evacuation route and habitable rooms. Specify evaluation criteria and test standards for the materials.

ASA Stds: Specify the installment standards for noncombustible materials which should be used for surfaces of walls and ceilings at least. Specify definite requirements for evaluation criteria set by MR.

MR: Specify the necessity of fire separation and types of fire separation.

ASA Stds: Specify target parts of fire separation which, in principle, consists of area separation, vertical opening protection, mixed-use separation, and separation at incidental use areas. Introduction of vertical opening protection and mixed-use separation is strongly recommended. Installment standards should include fire protective measures at openings and penetrated parts of fire barriers.

MR: Specify the necessity of smoke enclosure.

ASA Stds: Specify target parts of smoke enclosure ant its specifications.

MR: Specify the necessity of smoke control.

EIT Stds: Specify target parts of smoke control which include evacuation routes and habitable It is recommended to principally form smoke control by gravity/mechanical smoke exhaust systems.

12.3 MINISTERIAL REGULATION NO. 39

Points for the amendment of MR 39 are discussed below.

(1) Article 1

MR: Modify classification of building uses to be same with the definition of EIT standard.

EIT Stds: Same as recommendation in (1) of Section 12.2.

ASA Stds: Same as recommendation in (1) of Section 12.2.

(2) Article 4 and Article 5

MR: Specify individual definitions for detection systems and alarm/report systems.

EIT Stds: Same as recommendation in (3) of Section 12.2. In addition, specify the necessity of detection and alarm/reporting systems for building uses having occupants in sleeping conditions, such as hotels and hospitals.

(3) Article 6

MR: Devolve specification for type of detectors and alarm/report equipment and their installment standards to the EIT standard.

EIT Stds: Specify installment standards for detection and alarm/report systems.

(4) Article 7

MR: Specify the necessity of exit signs/exit sign illumination, and emergency lighting throughout evacuation routes.

EIT Stds: Specify installment standards including use of noncombustible and/or fire proof materials, installation height from floor surface, and illumination intensity, etc.

(5) Article 17 (1) and (2)

MR: Devolve specification for minimum time for emergency power supply to the EIT standards.

EIT Stds: Specify required time of power supply for each fire protection equipment and the installment standards.

(6) New Articles

MR: Specify the definition of hazardous materials.

EIT and ASA Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the use of noncombustible interior finish.

ASA Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the necessity of fire separation.

ASA Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the necessity of smoke enclosure.

ASA Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the necessity of smoke control.

EIT Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the definition of evacuation routes consisting of exit accesses, exits, and exist discharges which should have adequate width, fire/smoke resistance, continuity to a public way, etc.

ASA Stds: Specify installment standards in respect to the width, layout, and fire-resistance rating, etc. of evacuation routes.

12.4 MINISTERIAL REGULATION NO. 47

Points for the amendment of MR 47 are discussed below.

(1) Article 2

MR: Modify classification of building uses to be same with the definition of EIT standard.

EIT Stds: Same as recommendation in (1) of Section 12.2.

ASA Stds: Same as recommendation in (1) of Section 12.2.

(2) Article 5

MR: Focus the target buildings on these which were constructed before enforcement of MR 33 and classified into high-rise/extra-large/large buildings. Target buildings shall phased-widely cover other buildings smaller and newer than those buildings in the future.

(3) Article 5 (1) to (6)

MR: Specify the target level for improvement of existing buildings, aiming at evacuation safety which is the absolute requirements for life safety. The evaluation of building fire safety should relate to grading rules of new ministerial regulation currently under consideration by the Council of State. The technical requirements should include the following two basic conditions.

- Securing sufficient capacity of evacuation routes, corresponding to floor areas and number of occupants, to complete evacuation within proper time.
- Making vertical opening protections to confine the fire within a certain number of floors and secure safety of escape stairways.

Evacuation routes should be enclosed by fire separation, and doorways should be opened to the escape direction without any key or special devices.

The technical requirements should include alternatives, as listed below, in cases where an existing building can not be improved to meet with the basic conditions due to its physical limitation.

- Installment of balcony linking to supplement optional evacuation routes.
- Horizontal exit/Safety separation to secure an area of refuge where occupants may temporarily stay safely.
- Installment of evacuation equipment.

Other options should also be specified as listed below.

- Means imported from current MR 47 including installment of five fire preventive

measure:1) Portable fire extinguishers, 2) Fire detection/alarming systems, 3) Emergency lighting, 4) Layout plan of evacuation facilities, and 5) Lightning protection.

- Means newly introduced consisting of six improvement measures: 1) Public address systems, 2) Area separations, 3) Exit sign illuminations, 4) 24-hours management systems, 5) Window for firefighters, and 6) Fire drills.

  EIT and ASA Stds: Specify installment standards of improvement measures discussed above.

12.5 MINISTERIAL REGULATION NO. 48

Points for the amendment of MR 48 are discussed below.

(1) Article 2

MR: Modify classification of building uses to be same with the definition of EIT standard.

EIT Stds: Same as recommendation in (1) of Section 12.2.

ASA Stds: Same as recommendation in (1) of Section 12.2.

MR: Specify a reference document issued by DPT which stipulates technical requirements of the reliable institution in accordance with ISO17025.

MR: Specify the principle structure as all elements which have stability for structural loads. Walls and roofs should be newly introduced.

(2) Article 3 for Article 24 of MR 6

MR: Specify minimum size of buildings which needs fire-resistance rating.

EIT Stds: Specify the fire-resistance rating of principle structures by building uses, floor areas, number of floors, and type of structures. Stipulate specifications of applicable measures for the require rating.

In addition, specify the range of fire-resistance ratings which may be one to three hours for columns, beams, and walls and one to two hours for floors and roofs.

MR: Specify test standards for fire-resistance rating of principle structures in accordance with TIS and ISO standards.

EIT Stds: Specify test standards in accordance with TIS and ISO standards, especially ISO834.

(3) New Article

MR: Specify the necessity of fire-resistance rating for building elements.

EIT Stds: Specify the rating by each building element including fire barriers and fire protection equipment, such as fire doors and fire dampers.

12.6 MINISTERIAL REGULATION NO. 55

Points for the amendment of MR 55 are discussed below.

(1) Article 1

MR: Modify classification of building uses to be same with the definition of EIT standard.

EIT Stds: Same as recommendation in (1) of Section 12.2.

ASA Stds: Same as recommendation in (1) of Section 12.2.

(2) Article 27

MR: Specify the definition of evacuation routes consisting of exit accesses, exits, and exist discharges which should have adequate width, fire/smoke resistance, continuity to a public way, etc.

ASA Stds: Specify installment standards in respect to the width, layout, and fire-resistance rating, etc. of evacuation routes.

MR: Specify the necessity of evacuation routes corresponding to the number of occupants. The specification should include the necessity of multiple routes, maximum travel distance, and maximum common path of exit access travels.

ASA Stds: Specify installment standards for evacuation routes.

(3) Article 29

MR: Specify the necessity of sufficient width of outside escape stairways corresponding to the number of occupants.

ASA Stds: Specify required width of outside escape stairways.

MR: Specify the necessity of fire protection measure at openings within a certain distance around outside escape stairways.

ASA Stds: Specify fire-resistance rating for the openings.

(4) Article 30

MR: Specify the necessity of sufficient width of escape staircases corresponding to the number of occupants. In addition, specify the necessity of fire protection measure at openings in escape staircases.

ASA Stds: Specify required width of escape staircases and fire-resistance rating for the openings.

MR: Specify the necessity of emergency lighting and exit signs/exit sign illumination.

ASA Stds: Specify installment standards for guiding facilities mentioned above.

(5) New Articles

MR: Specify the definition of hazardous materials.

EIT and ASA Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the use of noncombustible interior finish.

ASA Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the necessity of fire separation.

ASA Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the necessity of smoke enclosure.

ASA Stds: Same as recommendation in (13) of Section 12.2.

MR: Specify the necessity of smoke control.

EIT Stds: Same as recommendation in (13) of Section 12.2.