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 I

SUMMARY

FEBRUARY 2003
THE BUILDING CENTER OF JAPAN
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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).

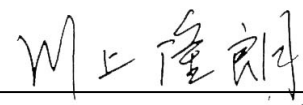
JICA selected and dispatched a study team headed by Mr. Yuji Kanaya of the Building Center of Japan, and consisted of the Building Center of Japan and Nippon Koei Co., Ltd., to the Kingdom of Thailand, seven times between July 2001 and January 2003. In addition, JICA set up an advisory committee headed 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 danger of 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 the established system of 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 promoting 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, which is currently under discussion.

- 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.

6) Promotion of Information Distribution and Human Resources Development: 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.

2. Amendments of Fire Codes

(1) Introduction of Passive Systems: to newly specify fire preventive measures based on the passive system such as the noncombustible interior finish, fire separation,

and smoke enclosures in fire codes with the consideration of current fire safety level in Thailand.

(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 definition about the classification of buildings, which is specified in fire codes, to be same with that specified in the EIT standard. In addition, the definition of hazardous materials in buildings needs to be specified.

(4) Proper Introduction of Fire Protection Systems:

- Strengthening requirement of installing 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 system by gravity and mechanical exhaust systems. Performance test should be introduced for the pressurized smoke control.
- Promoting installation of 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 that is under discussion, 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 such as building inspectors, architects, and building engineers.

VOLUME I: SUMMARY

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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 1: 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 2: REVIEW ON CURRENT SITUATIONS RETALED 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%.

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.

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.

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.

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.

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%.

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.

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 3: 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 4 : 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.

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.

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 Main 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 5: 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 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.

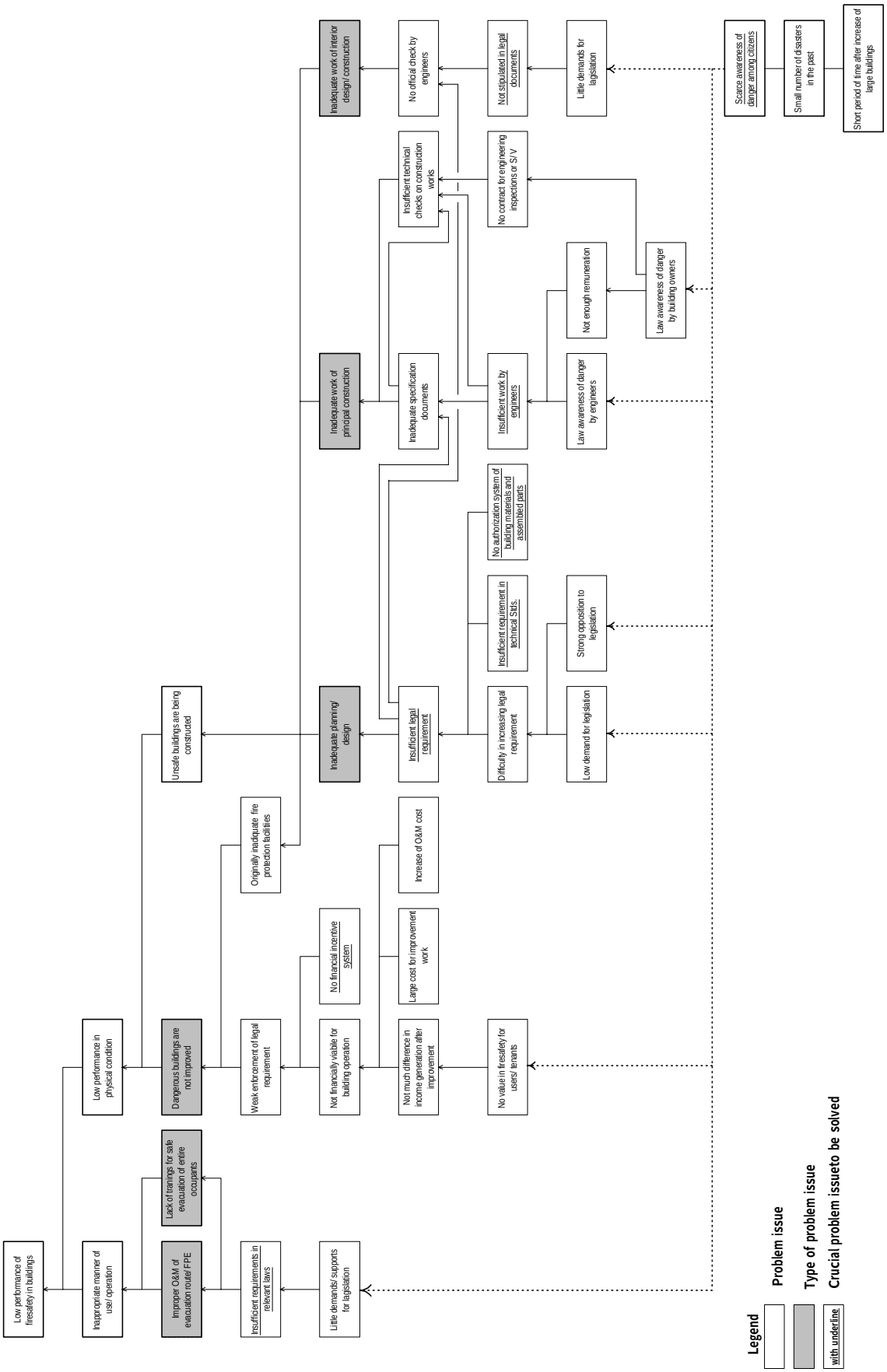

Figure 1: Problem Structure

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 6: 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.

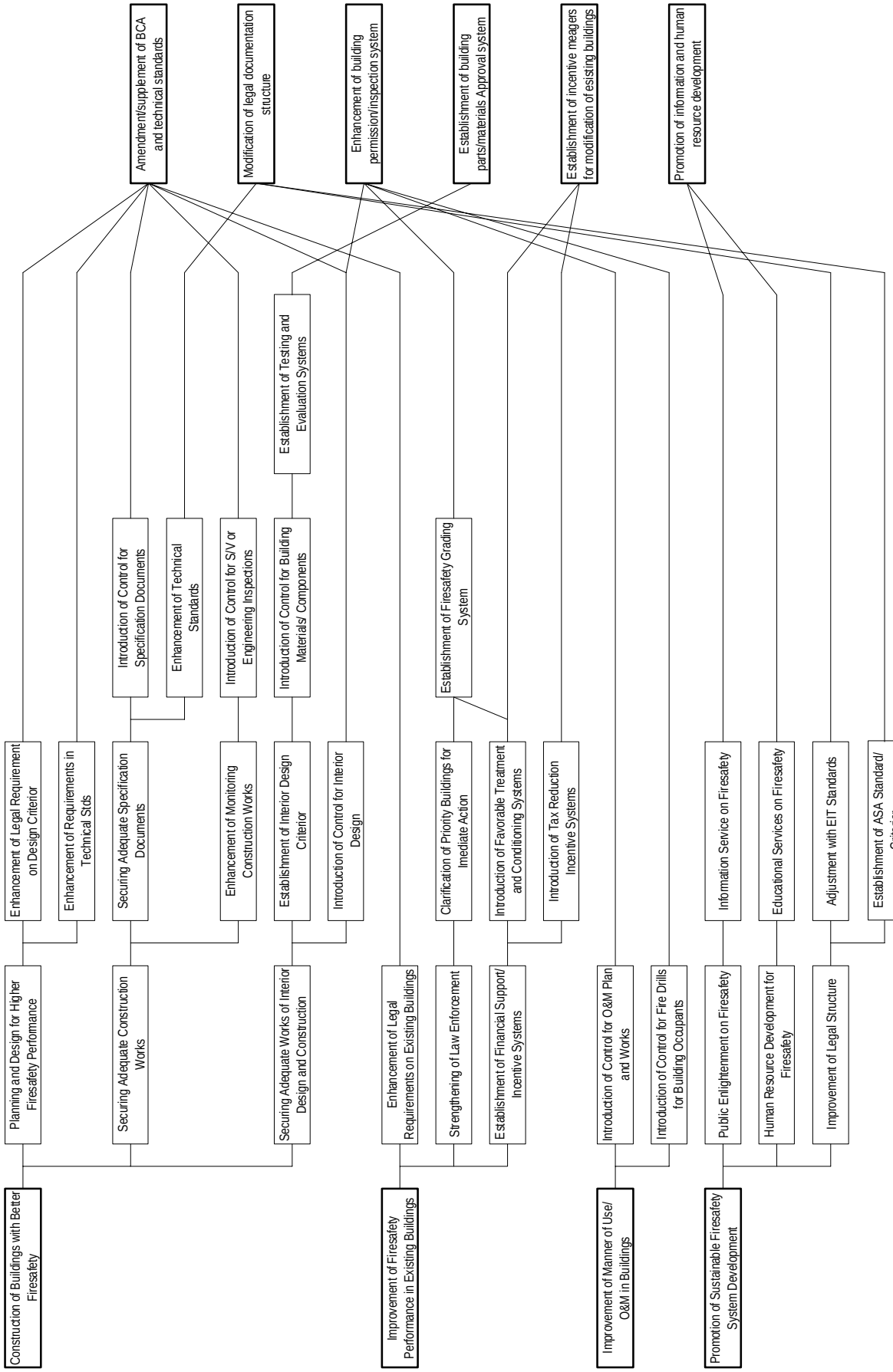

Figure 2 : Projects/Programs for Development Targets

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 II 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 3: 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 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:
RECOMMENDATIONS ON FIRE CODE AND TECHNICAL STANDARDS

CHAPTER 7: POINTS OF VIEW FOR RECOMMENDATION

7.1 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.

7.2 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 the Main 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.

7.3 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.

7.4 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 8: MAIN POINTS OF RECOMMENDATION ON TECHNICAL REQUIREMENTS

8.1 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.

8.2 PREVENTION OF INITIAL FIRE DEVELOPMENT

8.2.1 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.

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.

8.2.2 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.

8.2.3 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.

8.2.4 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.

8.3 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.

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.

8.4 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.

8.4.1 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.

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.

8.4.2 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.

8.4.3 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.

8.4.4 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.

8.4.5 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.

8.4.6 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.

8.4.7 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.
- 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.

$Q=\alpha t^2$ (kW)

$Af=Q/1,600$ (m^2)

(whereby, Q: heat velocity (kW), α: fire growth ratio (kW/s^2), t: time (sec), Af: horizontal area shadowed by a fire origin)

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.

8.5 FIRE FIGHTING AND RESCUE

8.5.1 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.

8.5.2 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.

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.

8.6 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.

8.7 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.

CHAPTER 9: IMPROVEMENT OF EXISTING BUILDINGS

9.1 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.

9.2 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.

9.3 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.