THE FUTURE OF FIRE SAFETY ENGINEERING IN JAPAN

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INTRODUCTION

For over a half century, development of engineering concept and methodology in fire safety measures was one of the principal focuses of fire research in Japan. Fluiddynamic modeling of fire plume, flame projection and single-zone modeling of fully developed room fires and quantitative modeling of evacuation behavior in the 1950s gave the first insight that fire can be a subject of normal science, and are now considered among the first significant success of engineering approach in fire safety technology. These achievements inspired many younger researchers to develop predictive method for various fire safety problems such as smoke movement in high-rise buildings and fire resistance of steel structures, which became recognized as a serious problem through the rush of the construction of high rise buildings during the high-growth period during the 1960s. Development in engineering based smoke control and structural fire safety design method during the 1960-70s gave building engineers and construction industry an idea to apply fire safety engineering to the design of actual buildings, mostly very tall buildings, whose construction began in the late 1960s in Japan. Performance oriented smoke control design of Shinjuku Center Building, the headquarter of Taisei Corporation, built in 1978 was one of the very early examples of the application of engineering approach in fire safety design in Japan. Partly because of the development and documentation of fire safety design method during the 1980s, there was significant increase of the application of engineering based fire safety design method to the design of actual buildings, mostly large-scale buildings and skyscrapers since the later 1980s even under the conventional specification based building regulation framework. They were conducted under the special Minister approval. This movement increased significantly the number of fire experts in construction industry and raised independent fire safety design consultants. The performance oriented overall revision of the Building Standard Law in 1998 - 2000 was a natural generalization of this trend, while there are still numbers of problems in the current fire safety regulation which need further reconsideration from the science and engineering point of view. Current application of performance based fire safety design is concentrated to super high rise buildings, large development such as shopping complexes, and buildings featuring large interior space and limited fire load such as museums, exhibition halls and arenas. On the other hand, the increase of high rise buildings itself do not have caused significant influence on the nature of fire safety design procedure despite its notable influence on the promotion of the development of fire protective materials and construction such as

concrete filled tubular construction. Most of conventional buildings have been long designed still according to prescriptive design guidelines. In such sense, while there has been notable growth in fire safety engineering and promotion of fire safety engineers during the last few decades, fire safety engineering deals with only very competitive construction projects and remains still a small part of the building design and engineering community. It can be said that research and development in fire safety engineering has been supported mainly by the national government taking care of building and fire safety regulations and large general contractors.

In summary, it can be concluded that during the late 20th Century, evolution of the profession and technical possibility in fire safety of buildings was led by research through the promotion of engineering approach in fire safety measures which was essentially necessary for the high-tech oriented development of building technology and design. This has established a small but stable and very active market of the application of fire safety engineering, mostly concentrated in highly competitive building projects whose need is believed not to be reduced in the near future. On the other hand, there is a strong and general belief that although medium height buildings have been generally designed only according to prescriptive regulations there is a growing need for the application of performance based design for such buildings in the future. This anticipation comes from the change of the social context with regard to fire safety in the near future in Japan. There are already many signs for such change in the social relevance of fire research to the social context. Then how will the research – engineering – practice relation become in this century?

SOCIAL CONTEXT OF FUTURE FIRE SAFETY OF BUILDINGS IN JAPAN

Demand in Construction and Building Market

The trend of construction market in the near future in Japan can be very much different from that during the last century. In this chapter, let us illustrate aspects of the construction market and public concerns on fire safety anticipated in the coming generation.

Urban Buildings

The total floor area of buildings all over Japan reached 13 billion m^2, roughly 100 m^2 for everyone of around 130 million total domestic population, in the year 2000. The recent significant increase of highly intelligent buildings in Tokyo has generated extreme vacant floors of relatively old office buildings. These facts suggest general saturation of the market of conventional office buildings and still continuous demand of highly intelligent buildings in the near future in Japanese big cities. Although this trend is obviously a sign for general

shrinkage of construction industry, it is believed that it would not impact directly the engineering oriented fire safety design nor the profession of fire safety engineers because the very competitive part of the construction industry has been the market of performance based fire safety design. The market of such competitive construction and subsequent need for technically advanced fire safety design is believed to be still growing.

Increasing need for repeated use of existing buildings can be a seed for the new development of performance oriented fire safety design. Even if new construction is decreased, there are significant stock of buildings which need either periodical renewal or conversion of central occupancies. These essentially need revisit on the compliance with frequently updated fire and other requirements, whose solution can be achieved, for most conditions, only through application of performance based fire safety design.

There is also a growing interest in the restoration and utilization of historic buildings. Administrative framework to encourage and support restoration of historic buildings including the historic landmark registration were enforced during the 1990s, and over 5000 historic buildings have been registered as the Cultural Affairs Agency's Registered Historic Monuments. It is also noteworthy that, during the last decade, modern buildings built in the early 20^{th} Century have become recognized as historic buildings while "historic building" had generally meant only pre-modern mostly wood based traditional buildings. Use of historic buildings as public buildings still basically needs compliance with fire safety regulation, and there are numbers of unfortunate application examples of prescriptive fire safety design which resulted only in either poor way of the building use or failure in authentic way of restoration. Most of such unfortunate cases would have been avoided if performance based fire safety design had been applied. Restoration of historic buildings is one of the field where future promotion of performance based fire safety design is expected.

Public Spaces and Urban Complex Development

Despite the general decrease of the demand for the new construction of individual buildings, there is growing interest in the development or redevelopment of more public urban spaces such as underground building complexes and traffic facilities. The on-going overall redevelopment around the Tokyo Station is its significant example; the total public floor area of the underground building complex within and around the Tokyo Station is expected to be larger than 400,000m^2 and the concourse floor of the station itself is becoming like a shopping mall. These urban public spaces and railway stations are currently not the subject of building regulation, and there are only few requirements for fire safety. However, this contempt of fire safety in public service facilities are only because of the anticipation of little fire load simple and generally open composition of the facilities and subsequent little risk and

hazard of fire. In view of the rapidly increasing introduction of commercial functions in such facilities, it is believed that there is rapidly growing fire risk and hazard in public service facilities.

Decrease of Domestic Population and Population Ageing

The national population of Japan began to decrease in 2005 with preceding long gradual drop of the birth rate. This trend is an another sign for the possible decrease of the interest in new construction, but on the other hand it reminds us of the need of further consideration of ageing in the fire safety of built environment. The aged rate is rapidly increasing in Japan; the rate of over 65 years old people is roughly 20% but is anticipated to reach 30% within a few decades, while the rate of still more aged population, say over 75 years old is believed to increase even faster, from roughly 9% in 2005 to 18% around in 2030. It has been widely recognized for long time that fire victims and fire causes concentrate to elderly people. While influence of the ageing in fire statistics is not yet very clear, statistics on such building disasters more sensitive to ageing as drowning in bath has indicated notable influence for over a decade. Influence in fire statistics could become clearer with the increase of the population of the higher-aged population because the perceptual and motile ability for evacuation is believed to reduce significantly from higher age, say around 75 years old. With the progress of ageing in Japan, consideration for aged people is becoming indispensable to cope with the following aspects.

(1) Rapid increase of “aged families” consisting of only aged family members
(2) Need and increase of elderly care and welfare facilities and hospitals
(3) Promotion of barrier-free environment in public buildings and facilities

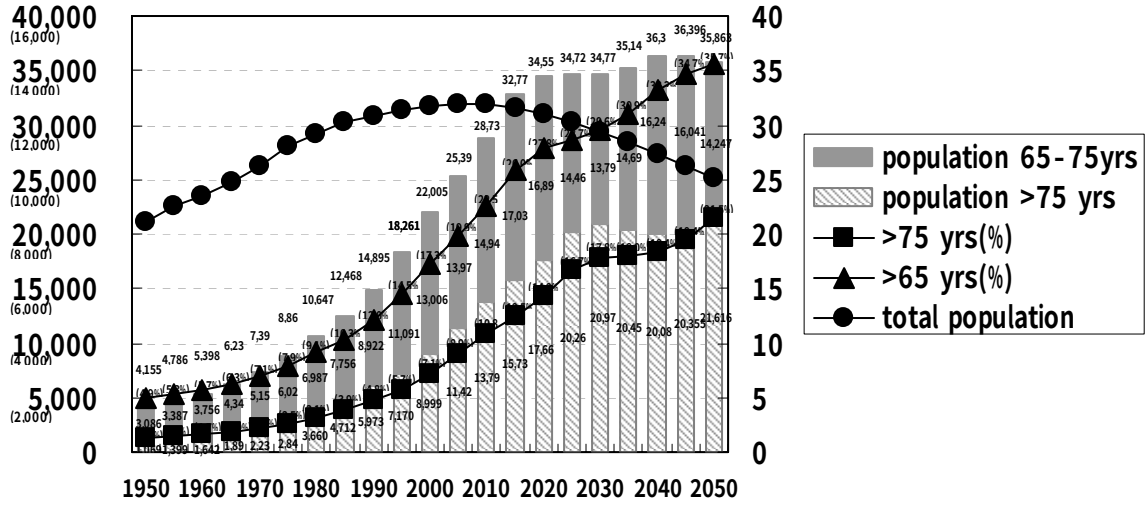

Figure 1 Change of Composition of the Japanese Population from 1950 to 2050(Census data until 2000 and estimate for future, both from the Government’s Statistics Bureau)

Healthcare and welfare facilities and hospitals are not yet subjects for the application of performance fire safety design, because of the lack in the tools, concepts and databases for the engineering oriented fire safety design for those people with major difficulty in the self-evacuation. Also, although general barrier-free design has become mandatory in public buildings, any new life safety requirements or regulations for elderly and handicapped do not yet have been introduced for barrier-free facilities. Increase of multiple-death fires in elder care facilities in quite recent years has called strong social attention to the fire safety in the living of elderly people. Need of the development of evacuation means for handicapped people is calling interest in the design of barrier free buildings.

Sustainable Buildings

Another most plausible change in building market relates to the growing interest in the development of environment-friendly construction technology. From the technical point of view, the focuses of the environment-friendly construction are the development of recycling technology of building resources and the reduction of the life cycle energy consumption.

Both concerns should have strong relevance with fire safety. Utilization of natural ventilation, a potent means for reducing life cycle energy consumption, has been believed to conflict with smoke control and achievement of “fire safe green buildings” should be an important subject for the promotion of the natural ventilation in buildings. Growing concerns in the sustainability of construction resources is causing strong interest in the promotion of the use of timber in buildings. It is generally because timber is essentially a naturally reproducible building resource and timber construction has been an important part of environment control in Japan, but because of the significant decrease of the consumption of domestic wood for a couple of decades in Japan, the forestry management is facing significant difficulty in maintaining the planted forests. Promotion of timber construction is often considered the symbol of the movement for sustainable buildings, but naturally promotion of timber construction will need advanced technical consideration on its fire and earthquake safety.

The planted wood resource in Japan has reached 2.5 billion m^3 and is growing at 80 - 90 million m^3 every year while its annual consumption is 20 million m^3, only less than one quarter of the growing rate of domestic wood resource. Interest in timber construction comes from different contexts, i.e. need of the development of sustainable construction resources, growing interest in the regeneration in historic districts and/or wood-producing districts utilizing historic and regional culture heritage and need of proper maintenance of local forestry and forest industry partly from global environmental point of view. As the high-tech and IT industries generally concentrate to mega city areas such as greater Tokyo, Kansai and Nagoya, historic heritage and traditional style buildings are becoming recognized as key

resource for the regeneration of smaller historic districts such as Kyoto, Kanazawa and other formerly feudal “castle cities”. Since in Japan the traditional and historic building technology has been out of the major interest of engineering and research in construction, there is obvious need in the research and technology to make historic and traditional buildings disaster safe.

Safety and Security Concerns of Public

Growing interest in disasters and security is also an important element that may affect the future of fire safety engineering. There is already some common recognition in public that many of big cities are threatened by earthquake and subsequent disasters and by terrorism and other disorderly acts. The Hanshin-Awaji Earthquake(1995) revealed the significant seismic and fire hazard in disorderly inhabited urban districts at the event of a big earthquake, and have reminded existence of large numbers of similarly or even worse disorderly and densely inhabited areas in mega cities. Because redevelopment has been proceeding only very slowly for the general difficulty in the coordination of interest and leasehold of the inhabitants, need to seek alternatives including improvement of seismic and fire safety performance of existing old low rise buildings is recognized as an urgent task for the safety of mega cities: however this approach should still need technical development for the simultaneous improvement of seismic and fire safety performance of wooden house buildings.

Lack and Needs of the Visibility in Fire Safety Performance

Fire safety design of buildings has been conducted generally with legal requirements as the ultimate criteria, whether the laws are prescriptive or performance based. However, because the fire regulations dictate only the minimal performance for general public, essentially they do not mention such fire safety aspects as property loss or indirect loss nor higher quality of life safety, e.g. for elderly or handicapped. With this background, there has been little effort to establish assessment and design method for fire safety aspects not covered by laws or for achieving higher quality of fire safety. The lack of appropriate measure to make the quality of fire safety visible has led to the general misunderstanding to take the code-compliancy as the ultimate goal of fire safety design, and is probably one of the reason why the present fire safety engineering remains still a very small part of building design and facility management. The population ageing, promotion of the use of existing buildings and other social and building aspects in the future is believed to diversity the demand of safety in buildings. However, unlike air conditioning or acoustic engineering, adequacy of fire safety design is not perceivable for general public or facility clients in everyday life unless any fire event takes place.

According to the experiences of large building fires, fire safety is crucial significance to many public buildings: occurrence of victim-causing fire in such public building as large shopping store, hospital and hotel normally destroys its business operation, and a fire of traffic facility can cause enormous impact on the business continuity and indirect loss to the local economy and social activities. If better fire safety design leads to the easier security management, it could be an important contribution of “performance oriented” fire safety design to the society. According to pioneering performance oriented fire safety designs of healthcare facilities and historic buildings, improvement of fire safety for specific interest beyond the legal requirement is a matter of design and does not need significant additional cost in the construction. In that sense, fire safety design to achieve rational quality of fire safety should be highly cost effective. There should be general potential demand for establishing measures to make the effectiveness of fire safety design visible from various points of interest not only from the legal compliance. Fire safety engineering does not yet seem to make enough efforts to respond to this shadow demand.

ROLES AND NATURE OF FIRE SAFETY ENGINEERING IN THE NEAR FUTURE

From the nature of the construction market and the fire safety concerns anticipated in the near future, subjects in fire safety engineering could be classified into the following three categories:

(1) Fire safety design and risk management which need further basic research for the development of basic design concept, database and so on
(2) Technical development of fire safety means and design method based on established technical concepts and methodology
(3) Application of established fire safety design methods and technologies

The first category includes fire safety for elderly people in welfare facilities and public buildings and so on. There is relatively little accumulation of research and scientific knowledge on the evacuation safety of elderly people in emergency and on the impact of earthquake on the fire safety performance of buildings. Engineering solution for these aspects of fire safety should essentially need new and more research approach.

Although the construction industry is very strong in research and development in fire safety there is still considerable difficulty in the promotion of industrial research on these subjects because the main interest of large construction firms focused for long time on rather large competitive buildings. Leadership by more public research bodies is needed for the development of engineering based fire safety measures on these topics. However, the quantity of the buildings and facilities that need solutions by fire safety engineering is so significant that there is essential need to develop cost-effective and industrially acceptable technical solutions.

Fire safety for business continuity, fire safety measures for underground buildings, environment-friendly buildings and renovation of existing buildings should also need further research and development. However, there is already a good engineering basis for these subjects in smoke control and structural fire safety.

Summarizing the analysis of the future Japanese market of construction and potential demand for fire safety, while the Japanese market of new construction is projected to decline notably in the future, the nature of the construction market anticipated in the future suggests general diversification of the demand for fire safety. It is a sign leading to the promotion of fire safety engineering, but at the same time it implies the current fire safety design and fire safety engineering only perceived as ways to achieve not the rational fire safety acceptable for building clients but only the legal compliance. For the real promotion of fire safety engineering, the author believes that fire safety engineers should develop tools to make fire safety performance achieved by fire safety design visible for general public. This must need not only better understanding of fire but also understanding of and coordination with facility management, other performances for buildings and so on. This part could be the really new aspect of “fire research” needed for the further and sustainable development of fire safety engineering.

CONCLUDING REMARKS

Despite the anticipated shrinkage of new constructions, it would not impact the current stream of fire safety design, which is competitive but still a very small part of building design and construction community. However, the accumulation of building stock and rapidly proceeding ageing in Japan is believed to cause significant change in the nature of the demand for fire safety engineering to maintain safe living and business environment. It will be a valuable opportunity to promote fire safety engineering as something more visible from society, and essentially need new framework for the organization of research, development and business/industrial application.

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