Effects of Fire Regulation Revisions on Building Fire Damage

Kyoichi Kobayashi

1 Center for Fire Science and Technology, Research Institute for Science and Technology, Tokyo University of Science, Japan

ABSTRACT

Between 1965 and 1974, there were many large building fires in Japan which resulted in numerous fatalities. In response, several revisions were made to the fire regulations for large buildings in the Building Standard Law and the Fire Service Law, leading to a decrease in such fires until about 1980. Extensive fire damage was frequently seen in old buildings with insufficient fire prevention features, so application of the fire regulation revisions to existing buildings was a crucial problem.

This paper compares the content and timing of fire regulation revisions, retroactive application to existing buildings, and time limits for retroactive application of each fire regulation with the average fire burned area of buildings in which fires originated according to usage and construction.

I examine the main causes of the sudden decrease in fire damage to large buildings from about 1970 to 1980, and show that the decrease is due to a sharp reduction in the number of large fires, owing to the retroactive installation of automatic fire alarm systems.

Keywords: Fire statistics, Average fire burned area, Building fire, Fire Regulation, Retroactive application, Effect of revision
1. INTRODUCTION

The Japanese Annual Fire Report\(^\text{Note1)}\) indicates that the yearly average area of floor space experiencing fire damage\(^\text{Note2)}\) (the "average fire burned area" below) ranges between 6 and 8 m\(^2\). In the early 1970s this figure was as high as 30 to 40 m\(^2\), but by around 1980 the figure had plummeted to around 10 m\(^2\), and despite repeated minor fluctuations has shown a slow decrease up to the present day.

Since the late 1960s, Japan has experienced rapid economic expansion and advances related to building technology, leading to a replacement of the previously dominant small, wood-framed non-residential structures with larger, more fire-resistive buildings. This in turn has led to another danger of fires in buildings.

By around 1970 conflagrations had almost disappeared, but taking their place were fires in large buildings that resulted in numerous fatalities. Prevention efforts included larger firefighting forces and revised laws for improved fire prevention features in

\(^{\text{Note1)}}\) The Annual Fire Report is a compilation of statistics related to fire disasters, published by the then Fire Department in the Ministry of Home Affairs annually since 1968. The report is published by the Fire and Disaster Management Agency Disaster Information Office.

\(^{\text{Note2)}}\) The current treatment guidelines for the Annual Fire Report (Fire and Disaster Management Agency) in the Second Annual Fire Report 4(4) define “fire damage area of the fire source building” as follows: “When the fire damage in the reported building occurred in three dimensions, the floor space of the portion of the area that has lost functionality is calculated in square meters. Note: the floor space of that portion of the area that has lost functionality refers to the floor space of the area surrounded by either the floor or the ceiling and at least two surfaces that experienced fire damage.” The term “fire damage floor space” was first defined in the 1994 revised treatment guidelines for the Annual Fire Report, and previous to that the term “fire burned area” was used with almost exactly the same meaning. The definition of “fire burned area” was as follows: “Enter the area calculated according to the instructions for calculating the total area of that portion of the building that is no longer usable due to fire damage. When fire damage occurred in three dimensions, the floor space of that area is calculated as per the calculation instructions. This calculation gives the fire burned area, and is measured in square meters. Buildings are three-dimensional structures and must function as such, but the fire burned area is defined as the floor area of the part that has lost its function as a result of fire damage. [The remainder of the definition is omitted here.]” As discussed in Section 2, this paper uses data from 1968 through 1993 for its analysis, so in the remainder of this paper the term “fire burned area,” not “burned floor space” will be used, according to the definition above.
buildings. The sudden decrease in average fire burned area in the 1970s was likely due
to the effectiveness of these measures.

This study examines changes in the average fire burned area of buildings in which
fires originated by usage and construction alongside the history of revisions to Building
Standard Law and Fire Service Law. This investigation should clarify the effectiveness
of the various fire prevention efforts put into place at that time.

Previous analyses using building fire burned area include the following. Murai
et al.[1], Shida et al.[2], and Suzuki et al.[3] have performed statistical analysis on
the effect of suppressing fire damage through fire protection measures. Murai et al.
described the distribution characteristics of fire burned area in buildings, and presented
a factor analysis of the effects of daily maintenance and fire protection and alarm
systems on those distribution characteristics. Shida et al. and Suzuki et al. analyzed the
effects of daily maintenance and fire protection and alarm systems on the distribution
characteristics of fire burned area. Suzuki[4] researched the expected value of building
fire loss with a focus on industrial classification. Sato et al.[5] and Kurioka et al.[6]
researched the ratio of fire burned areas in offices, factories, and hospitals. Nii et al.[7]
investigated the risk of fire spread in buildings.

Each of these studies analyzes trends in fire burned area with a focus on the usage,
construction, scale, or installed fire prevention equipment of the building that was
the source of the fire. Revisions of fire regulations are not considered in these studies.
Furthermore, the coverage of data used in these studies starts in 1995, the year from
which digital data about fires became available. Therefore the sudden decrease in fire
burned areas over approximately the decade of the 1970s, especially from the view point
of revisions of fire regulation in those days, remains unexplained.

Sekizawa et al.[8] explored the reliability of fire burned area data, and noted that
reporting firefighting organizations may use different methods for calculating statistics.
However that study examines trends in nationwide statistics, making it likely that any
effects from such differences can be ignored.

The Annual Fire Report contains a listing called the “Damage of Building Fires by
Source Building Usage and Construction,” which gives information related to the fire
burned area of buildings in which fires originated by usage and construction. This data
has been compiled since 1968, and previous data is unavailable. Furthermore, portions
of the 1968 data used different categorizations for usage and construction, requiring
some adjustment. Notes related to such adjustments are included as necessary. Other
discontinuities in the data include changes to structural classifications in 1994, and
further changes to usage classifications from 1995 and beyond.

Because the primary goal of this study is an analysis of the sudden decrease in fire
burned area in fire-resistive buildings since the 1970s, analysis was performed on data
from 1968 through 1993. Unless otherwise noted, data used in this study is from the
“Damage by Building Fires by Source Building Usage and Construction” listing in the
Annual Fire Report.
2. AVERAGE FIRE BURNED AREA OF BUILDING FIRES

2.1 Overall Statistics

Fire burned area in buildings is closely related to the efficacy of the local fire department and the performance of fire prevention measures. Considering trends in average fire burned area therefore allows a comprehensive view of improvements in such areas.

Figure 1 shows the average fire burned area of buildings from 1968 to 1993[9]. The graph shows that average fire burned areas fell about 29% gradually but steadily from around 42 m$^2$ in 1968 to around 30 m$^2$ in 1993.

The possibility that reinforcement of fire resources contributed the reduction of average fire burned area should be tested. Figure 2[10] shows the number of fire engines with pumps$^3$ in the same period. The graph shows that the number of fire engines with pumps increased by about 35%, from around 17,000 in 1968 to around 23,000 in 1993. The trend appears inversely proportional to the trend of average fire burned area.

\begin{figure}
\centering
\includegraphics[width=\textwidth]{figure1.png}
\caption{Average fire burned area (m$^2$) for building fires (1968–1993)}
\end{figure}

Note$^3$ Number of fire engines with pumps: total number of fire engines with pumps of both full-time and volunteer fire brigades, from Fire Service White Paper (1968-1993).
ConflagrationsFootnote 4 often occurred before the 1970s in Japan (Figure 3), and affected the average fire burned area of buildings. Conflagrations were rare after the 1970s.

Footnote 4 Appendix II-8 in the 2011 Fire Service White Paper defines conflagrations as fires exceeding 33,000 m² total fire burned area in buildings. Here, data for large factory fires is excluded.
Table 1 lists the conflagrations that occurred between 1968 and 1993. Only the 1976 fire had a significant influence on data averages.

Table 1 Conflagrations 1968-1993

| Year   | Name of conflagration | Burned buildings | Fire burned area in conflagrations (A m²) | Year’s total fire burned area in Japan (B m²) | (A)/(B) ×100 (%) |
|--------|-----------------------|------------------|-------------------------------------------|---------------------------------------------|-----------------|
| 1968   | Ohdate City Fire      | 281              | 37790                                     | 2,245,673                                   | 1.7             |
| 1969   | Kaga City Fire        | 68               | 33846                                     | 2,555,551                                   | 1.3             |
| 1976   | Sakata City Fire      | 1774             | 152105                                    | 2,267,147                                   | 6.7             |

(Source: Appendix II-8 in Fire Services White Paper 2011)

2.2 Average Fire Burned Area by Structure Type

Buildings in Japan are constructed as fire-resistive, quasi fire-resistive, fire-preventive, or wooden structures. Fire burned area varies greatly with the structure type of the building where the fire occurred.

Figure 4 shows average fire burned area by structure type for 1968–1993 in the years for which data are available. Each line in the figure indicates average fire burned area of the four structure types mentioned above. As the table shows, the burned area is largest in wooden constructions, and smallest in fire-resistive constructions.

The following can be discerned from this graph:

1) The overall average fire burned area gradually declined from approximately 65 m² to approximately 50 m².

2) The average fire burned area of wood construction buildings fell by approximately 12.5% between 1968 (73.4 m²) and 1975 (64.2 m²).

3) The average fire burned area of fire preventive buildings showed a slight increase between 1968 and 1971 to an average 43.4 m², but then fell 28.8% to 30.9 m² in 1975 and remained roughly the same thereafter.

4) The average fire burned area of quasi-fire-resistive buildings remains approximately 64.7 m² between 1969 and 1980. That is followed by an extended period at approximately 57.6 m² from 1981 to 1993; a relatively flat stretch, yet still a reduction of approximately 11%. Note that there was no “quasi-fire-resistive building” category in the 1968 data.

5) The average fire burned area of fire-resistive buildings increased from 24.4 m² to 41.0 m² between 1968 and 1970, but following that dropped 70% to 12.1 m² in 1976. Following that has been a general downward trend, despite sporadic increases, to a stable value of approximately 8–9 m² since 1984.
The following are likely reasons for the changes in average fire burned area by structure type discussed above:

1) While items 2) through 5) above indicate individual variations over time, the overall trend is one of reduction, as described in item 1). A primary reason for this phenomenon is that during this period the ratio of wooden structures fell as they were replaced by fire-resistive or fire-preventive buildings, which tend to have smaller average fire burned areas. Change in the ratio of fire damage by building type is thus likely a reflection of changes in the number of buildings of each type (Figure 5).

2) The average fire burned area of quasi fire-resistive buildings, which one would expect to have superior fire resistance properties to wooden or fire-preventive buildings, is approximately the same as the former’s and higher than the latter’s. This is because 43% of buildings with quasi-fire-resistive structures were used in factories or workplaces, many of which were located in large spaces without fire compartments\(^5\). This means that failure to control fires at the earliest stages often led to larger fire burned areas.

\(^5\) For factories and other buildings with usages that place them in this category, in situations where factors related to usage prevent other solutions, the requirement for fire compartmenting using quasi-fire-resistive construction floors, walls or fire doors for each 1500 m\(^2\) of floor space shall not apply (Order for Enforcement of the Building Code, Article 112, Item 1 Paragraph 1).
3) Variation in the average fire burned area of wood or fire-preventive structures was likely due to these buildings most commonly being small detached residences, upon which fire regulations have little effect. Numerous other influences likely exist, including firefighting services, materials used for interiors and furnishings, lifestyle patterns, and social structures, but such factors are beyond the scope of this paper and therefore not addressed further.

4) Variation in the average fire burned area of fire-resistive buildings is clearly both large and sudden as compared with variation in the fire engines with pump (Figure 2).

5) Variation in the average fire burned area of fire-resistive buildings is large as compared with other structural types, seemingly for other reasons. There were numerous revisions to fire regulations in Japan between 1965 and 1975, which possibly had a significant effect on this building type. The remainder of this paper will explore this possibility.

![Figure 5 Ratios of building fires by structure type (1969–1993)](Source: Annual Fire Report, “Building Fires by Fire Source Building Usage and Construction”)

3. REVISION OF FIRE REGULATIONS AND AVERAGE FIRE BURNED AREA OF FIRE-RESISTIVE BUILDINGS BY USAGE

3.1 Revision of Fire Regulation Since the 1960s

A survey on the revisions of fire regulations between 1965 and 1975 was carried out to search for reasons for reduction in the average fire burned area of fire-resistive buildings during the same period.

Before 1961, the construction of buildings exceeding 31 m in height was generally not allowed in Japan. In 1961, however, the “specified blocks” system was enacted, and in 1963 a “bulk district” system was put in place, measures that meant absolute building
height was now limited by the ratio of lot area to total floor space, with the expectation that numerous high-rise buildings would be developed. Furthermore, this was a period in which many underground malls connected to train stations were developed.

Because evacuations and firefighting operations are extremely difficult in high-rise buildings and in underground malls, posing high risk for loss of human life, revising fire regulations to account for these new features became an important topic[12].

Another factor was numerous fires in fire-resistive buildings at resorts and hotels from the late 1960s onward that resulted in multiple fatalities, including the May 1972 Sennichi Department Store Building fire, which with 118 fatalities was the worst fire disaster in Japan since the 1948 establishment of a modern fire department system. That was followed closely by the November 1973 Taiyo Department Store fire, which resulted in 100 fatalities.

Table 2  Fire disasters with multiple fatalities

| Date   | Location and name of burned building                  | Fatalities |
|--------|-------------------------------------------------------|------------|
| Jan-66 | Kanagawa Pref., Kanai Building                        | 12         |
| Mar 1966 | Gunma Pref., Minakami Hot Springs Kikufuji Hotel   | 30         |
| Mar 1968 | Tokyo, Asakusa International Theater                 | 3          |
| Nov 1968 | Hyogo Pref., Arima Hot Springs Ikenobo Mangetsujo Hotel | 30         |
| Feb 1969 | Fukushima Pref., Bandai Atami Hot Springs, Banko Hotel | 30         |
| Aug 1970 | Hokkaido, Teine Hospital                              | 5          |
| Jan 1971 | Wakayama Pref., Sushi Yoshiro Hotel                  | 16         |
| Jan 1971 | Hokkaido, Bibai Hairdressers Dormitory                | 10         |
| Feb 1971 | Miyagi Pref., Oshima Hospital                        | 6          |
| Feb 1971 | Chiba Pref., Kiritomo Gakuen Daycare                 | 5          |
| Feb 1972 | Wakayama Pref., Tsubaki Grand Hotel                  | 3          |
| May 1972 | Osaka, Sennichi Department Store Building             | 118        |
| Nov 1973 | Kumamoto Pref., Taiyo Department Store                | 100        |

(Source: Fire Services White Paper and “112 Case Studies of Fires” (see Note 9))

There were various direct causes that led to the high fatality rates in these fires, but the broad reason was a gap between the peculiar requirements for fire disaster prevention in these newly popular large buildings and their construction, the fire protection and alarm systems installed in them, and the firefighting and emergency evacuation methods when a fire did occur. As a result, these disasters led to multiple revisions and strengthening of the fire regulations of the Building Standard Law (“building code,” below) and fire regulations of the Fire Service Law (“fire code,” below) between 1964 and 1974. Appendices 1 and 2 show the main revisions, classified into each fire prevention measure and arranged according to the date of enactment.
The revisions to the building codes with a particular effect on reducing average fire burned area included strengthened fire compartments (pit compartments\(^\text{Note6}\), especially) and restrictions on interior materials. Particularly effective fire codes included retroactive application of automatic fire alarm systems (“fire alarms,” below) and automatic sprinkler systems (“sprinklers,” below), and expanded fire prevention management systems\(^\text{Note7}\).

### 3.2 Revision and Retroactive Application of Fire Regulations

Strengthened fire-related rules will have no statistically significant effect unless the buildings for which such rules are applicable are some minimum ratio of the total. When Japanese building codes are revised there is generally no need for existing buildings to retroactively conform to the new standards immediately: buildings need only be brought into compliance when they next undergo expansion, renovation, or large-scale remodeling or repair \(^{r1}\). Changes in building codes are therefore unlikely to have a statistically significant effect for some time, and reductions in average fire burned area will not be seen until enough buildings have undergone renovations and so forth. It is therefore difficult to point to the building code revisions as a primary reason for the sudden decrease in average fire burned area seen in fire-resistive buildings between 1970 and 1975.

---

\(^{r1}\) pit compartment: fire compartment between every pit (staircase, escalator, elevator shaft, pipe shaft, atrium, and so on) and other parts in a building.

\(^{Note6}\) Of those architectural elements associated with fire prevention, fire compartment to prevent the spread of fires, and the use of fireproof and flame retardant materials, likely contribute the most toward lowering fire burned areas. Emergency evacuation facilities such as emergency stairs cannot be expected to lower fire burned areas. Emergency elevators and other firefighter support equipment should contribute toward lowering fire burned areas, but there were very few fires in high-rise buildings at the time, and there were no reported cases where such facilities are expected to have had an effect, and thus they are not be discussed here.

Automatic sprinklers are the fire prevention equipment expected to most reliably contribute toward lowering fire burned area, especially when combined with other equipment incorporating elements of human participation such as fire alarms, fire extinguishers, and indoor fire hydrants. There is also a chance that fire prevention management systems put into place at this time contributed to increased reliability of human elements. Consolidated sprinklers should contribute to lowering fire burned areas in basements, but since no cases where they did so have been identified, these are not covered. Emergency evacuation equipment cannot be expected to lower fire burned areas. There is also a chance that flame retardant materials such as those used in curtains made a contribution by keeping fires smaller at the beginning, but this possibility is not investigated.
Fire codes, which mainly regulate installation of fire protection and alarm systems, also follow a similar line of thought. However, the details of implementation differ, because it is not technologically difficult to install equipment in an existing building, as compared with changing the building itself [r2]. For example, fire protection and alarm systems such as fire extinguishers and escape ladders, which are easily installed in existing buildings, should be retroactively required immediately or within some time from enactment of the revised regulation [r3]. Kinds of fire protection and alarm systems required to be retroactively installed are prescribed by cabinet order. Fire protection and alarm systems that are directly related to reducing average fire burned area include portable fire extinguishers and fire alarms.

Regulation of fire alarms was not previously a retroactive requirement, but the October 1966 revisions mandated retroactive requirements for “designated buildings of cultural significance.” [r4] Several subsequent cases of fatal fires in hotels and hospitals led to additional revisions in March 1969 that expanded mandatory installation to hotels and hospitals [r5]. The numerous fatalities in the May 1972 Sennichi Department Building fire led to still further revisions in December 1972 that expanded such requirements to all buildings in which a fire could lead to extensive loss of life (“designated use buildings,” see Table 5) [r6].

Despite such measures, the November 1973 Taiyo Department Store fire in Kumamoto resulted in many deaths, and the Fire Code was revised in June 1974. According to the new revision, regulations for all fire protection and alarm systems were retroactively applied to designated use buildings [r7]. Among the fire protection and alarm systems to which retroactive requirements were newly applied at that time, indoor fire hydrants and sprinklers are directly related to reduction in average fire burned area.

Table 3 summarizes the periods of retroactive application of fire codes discussed above.

| Date of enactment | Type of building addressed | Equipment retroactively required | Deadline for retroactive application | Grace period |
|-------------------|---------------------------|---------------------------------|-------------------------------------|--------------|
| 10 Mar 1969       | Hotels and hospitals      | Fire alarms                     | 31 Mar 1971                         | Approx. 2 years |
| 1 Dec 1972        | Buildings subject to specific fire protection | Fire alarms                    | 31 Nov 1975                         | 3 years      |
| 1 Jun 1974        | Retail stores, underground malls, and multiple-use buildings subject to specific fire protection that include specified uses | All fire protection and alarm systems | 31 Mar 1977                         | 2 years, 10 months |
|                   | Buildings subject to specific fire protection other than the above |                                  | 31 Mar 1979                         | 4 years, 10 months |
From enactment of the Fire Services Law in 1948 through 1960, fire prevention regulations were set at the city or town level; regulations related to fire protection and alarm systems were finally unified throughout Japan by the 1960 revisions. As of 1969, therefore, some cities and towns could have many buildings built in 1960 or earlier that did not have the fire protection and alarm systems that would be installed in buildings built in a later year. As described above, retroactive application of requirements for installing fire protection and alarm systems results in the appearance of fire alarms and sprinklers within a relatively short time, which should become a primary reason for a marked decrease in average fire burned area.

4. AVERAGE FIRE BURNED AREA IN FIRE-RESISTIVE BUILDINGS BY USAGE

Comparison of the timing of retroactive installation of fire protection and alarm systems and the timing of reduction in average burned area allows an estimation of the effectiveness of such measures. Figure 7 shows a summary of changes in average fire burned area in fire-resistive buildings by usage according to the Annual Fire Report from 1968 to 1980 in consideration of the information in Table 3.

Note 8) Prior to 1995, there was not always perfect agreement between the usage categories that are the subject of Fire Department directives and those used in the Annual Fire Report. Usage classifications are therefore made as per Appendix 3.

- Classification by the Order for Enforcement of the Fire Service Law, Supplemental Table 1: Some items in the “bathing facilities” category may contain data from the Item (9)a category, but because there should not be a qualitatively significant amount, these are classified as buildings not subject to specific fire protection.
- “Dwellings” have been set apart from other buildings not subject to specific fire protection, for the following reasons:
  a. Until 2004 single-unit dwellings were not subject to the Fire Service Law concerning fire alarms and other fire protection and alarm systems.
  b. Until 1995 requirements of the Fire Service Law regarding creating partitions of 70 m² or less (until 1975) or 100 m² or less (until 1986) and certain fire prevention measures were rarely applied to apartments.
  c. Restrictions on interior materials were not applied to apartments with partitions of 100 m² or less (until 1987) or 200 m² or less (to the present) (Order for Enforcement of the Building Code, Article 129).
  d. Residences were also excluded from requirements for pit compartments (Order for Enforcement of the Building Code, Article 112, Item 9).
Figure 7 is complex and difficult to read, so I present its components as graphs 7-1 through 7-3, and explain them individually.

Few buildings built before the extensive strengthening of the Fire Code in 1965 had fire protection and alarm systems including fire alarms. As Table 3 shows, in March 1969 the order for Enforcement of the Fire Services Law required retroactive installation of fire alarms in only hotels and hospitals greater than a specified size by March 1971. A reduction in average burned area during that period for other usages in advance of hotels and hospitals would be a strong indication that, among the various fire protection and alarm systems installations, fire alarms in particular make a strong contribution toward reducing average fire burned area. Figure 7-1 was constructed to investigate this possibility.

The following can be seen from Figure 7-1:

1) Although there was some increase in 1972, hotels to which standards pertaining to fire alarms were retroactively applied in 1969–1971 showed an overall subsequent decline in average fire burned area.

2) Hospitals to which the same standards were applied, however, showed no such decrease.
Figure 7-1 Average fire burned area in fire-resistant hotels and hospitals (1968-80)

Most buildings constructed before 1965 did not have fire alarms or other predominant fire protection and alarm systems, nor did most designated use buildings other than hotels and hospitals. As Table 3 shows, the Order for Enforcement of the Fire Code was revised in December 1972, and required retroactive installation of fire alarms in all designated use buildings of a specified size by November 1975.

The Fire Code was further revised in June 1974 to require other fire protection and alarm systems such as indoor fire hydrants and sprinkler systems by March 1977 for retail stores and underground malls, and by March 1979 for theaters, restaurants, hotels, hospitals, and elderly care homes. Because the deadline of retroactive installation differs between fire alarms and other fire protection and alarm systems, and also differs among retail stores, underground malls, and different types of designated use building, comparison of differences in average burned area reduction over those periods might allow for narrowing the possibilities for which types of fire protection and alarm systems have the highest effect on reducing average burned area. Figure 7-2 was created to that end.

Figure 7-2 indicates the following results:

1) Retail stores showed a marked decrease in average fire burned area from 1972 to 1975 (the period during which standards for fire alarms were retroactively applied), but the period from 1974 to 1977, during which all standards pertaining to fire protection and alarm systems were retroactively applied, showed no trend toward reduced average fire burned area.

2) Designated use buildings other than the three types described (which includes restaurants, stage and movie theaters, entertainment venues, and social welfare facilities) show a reduction in average fire burned area during 1968 through
1972, before the retroactive application period, but no such trend during the period of retroactive application.

**Figure 7-2** Average fire burned area in fire-resistive retail stores and other designated use buildings (1968–80)

1. Retroactive application of fire alarms to all designated use buildings
2. Retroactive application of all fire protection and alarm systems to retail stores
3. Retroactive application of all fire protection and alarm systems to designated use buildings (except retail stores, underground malls, and multiple-use buildings)

**Figure 7-3** shows the graph about houses and nonresidential buildings other than designated use buildings picked up from **Figure 7**.

**Figure 7-3** shows the following:
1. Houses show no reduction in average fire burned area over the entire period.
2. The average fire burned area of nonresidential buildings other than designated use buildings gradually declined from the 1970 figure (43.0 m$^2$), falling to less than half that value (17.7 m$^2$) over six years. That value is lower than that for other non-hospital designated use buildings, but the trend reversed in 1971 and 1975 showed higher values than for others (except for hotels in 1980).
Figure 7-3  Average fire burned area in fire-resistive houses and nonresidential buildings other than designated use buildings (1968–80)

Overall, the graphs above indicate a high probability that the period of retroactive application of regulations pertaining to fire alarms was effective. They suggest differences between designated use buildings and other buildings, but this figure does not allow for ascertaining the difference in the effectiveness of retroactive application of regulations pertaining to equipment other than fire alarms.

5. DISCUSSION

5.1 Data Reliability

The Fire and Disaster Management Agency produces the Annual Fire Report using data according to the Instructions for Handling Fire Reports [r8] from fire investigations conducted by local fire departments, compiling it into an annual report. Not only might there be differences between individual fire officers and fire stations performing fire investigations, but the following items may also be factors that influence this study.

(1) Building classifications

The term “fire-resistive building” should be a classification applied to those buildings that meet the established standards or whose main structural components are fire-resistive, but as of 1970 there were many mixed-case structures where fire-resistive buildings were added as expansions to wooden buildings or fire-preventative structures.
This is for the following reasons:

1) There were no nationwide standards for buildings before the implementation of the Building Code in 1950.

2) After the Law was implemented, main structural components of buildings for specific uses or of a given floor space should be fire-resistant [r9], but the term “fire-resistant building” was not fully defined until 1959.

3) In 1951 there was de facto recognition of buildings partitioned in certain ways (e.g., using Class A fire doors or fire-resistant walls at the interface between wooden portions and fire-resistant structures) as wooden or fire-preventative structures to which fire-resistant structures had been added [r10].

Local fire departments could report the fire burned area of burnt mixed-structure buildings in any category of wooden structure, fire-preventative structure, or fire-resistant structure. As the fire burned area of a mixed-structure building is often large, such effects of classification cannot be ignored. For example, the total fire burned area for “fire-resistant” hotels was 8942 m$^2$ in 1968, but according to the data in “An Analysis and Evaluation of the Danger Posed by Fires: 112 Case Studies of Fires” [Note9] (“112 Case Studies of Fires,” below), as shown in Figure 8 the fire burned area of the Fukuzumi Inn and Shirakabako Hotel, which were classified as “fire-preventative, partially fire-resistant,” was 732 m$^2$ (8.2%) and 1384 m$^2$ (15.5%), respectively, and that of the Ikenobo Mangetsujo Hotel, which was classified as “fire-resistant, partially wooden,” was 6950 m$^2$ (77.7%). If these are classified as “fire-resistant buildings” in the Fire Report for that year, then they have an extremely large effect on average fire burned area, but at this point it is difficult to ascertain whether that was the case.

---

**Note9** “An Analysis and Evaluation of the Danger Posed by Fires: 112 Case Studies of Fires” (Tokyo Fire Department Administration Study Group, Zenkoku-Kajo-Horei Publishing, 1981) is a compilation of 112 case studies from inquiries made by the Tokyo Fire Prevention Council, Human Life Measures Subcommittee to evaluate the disaster prevention performance and develop plans to ensure the safety of human life. Cases were selected according to the following criteria: Events examined were domestic building fires occurring in 1932 and since 1952, mainly those classified according to the Order for Enforcement of the Fire Service Law Supplemental Table 1 as Item (4) (retail stores), Item (5)a (hotels), item (6)a (hospitals), or item (16)a (multipurpose buildings subject to fire prevention). Events are fires falling into one of the following categories:

1. Fires with fire burned area exceeding 1000 m$^2$
2. Fires with fire burned area between 500 m$^2$ and 1000 m$^2$, in which fatalities occurred
3. Fires with fire burned area under 500 m$^2$, in which at least three fatalities occurred
4. Fires with unusual routes of spreading
5. Fires with highly specific causes
6. Other fires that might help plan for fire prevention.
Figure 8 Comparison of total fire burned area in large hotel fires in 1968

Figure 9 shows data for fires at fire-resistant buildings and mixed-structure buildings that include fire-resistant components, extracted from the 1965–1980 data in “112 Case Studies of Fires.” The figure shows that mixed-structure fires had a high share of the total from 1968–1969, but following that period the ratio dropped off.
(2) Multipurpose building categories

Because there was no category in the “Damage by Building Fires by Source Building Usage and Construction” section of the 1968–1993 Annual Fire Report for buildings used for multiple usage categories (multipurpose buildings), the primary usage of fire source buildings is the basis for reporting, as if the fire occurred in a building of solely that type. According to Fire Code, multipurpose buildings are referred to as “multipurpose fire-preventative buildings,” a term that was introduced in 1974 as a result of the Sennichi Department building fire [r11]. A precise definition and operational policy was clarified in 1975 [r12]. This means that there is a probability that data earlier than 1975 are slightly unreliable regarding the usage category of buildings for which fires were reported.

Meanwhile, Table 4 presents the 1968–1980 data from “112 Case Studies of Fires” regarding fires in fire-resistive buildings or mixed-structure buildings with fire-resistive components, and many of these fires were extensive. When compiling fire reports, therefore, the manner in which these buildings are classified will have an extremely large effect on the average fire burned area by usage category, but it would be difficult to confirm this information now.

Table 4  Fires exceeding 100 m² in fire-resistive multipurpose buildings (1968–1980)

| Year  | Burned building                  | Fire burned area (m²) |
|-------|----------------------------------|-----------------------|
| 1968  | Bronze Hall                      | 1105                  |
| 1969  | Hayashi Building                 | 740                   |
|       | Kamata Cultural Center/Ito Yokado| 1782                  |
| 1970  | Mito Central Building            | 10476                 |
| 1971  | Himeji International Hall        | 1844                  |
| 1972  | Sennichi Department Store        | 8763                  |
| 1973  | No. 6 Pole Star Building         | 285                   |
| 1975  | Ikebukuro Asahi Hall            | 811                   |
|       | Shibuya Nanatenkai Building      | 592                   |
| 1976  | Sekine Building                  | 505                   |
|       | Imai Building                    | 339                   |
|       | Misawa Building (Rakuraku Bar)   | 256                   |

(Source: “112 Case Studies of Fires”)

5.2 Differences in Trends of Average Fire Burned Area between Hotels and Hospitals

While retroactive application of regulation for fire alarms significantly reduced the damage of fires in hotels, this is not the case for hospitals. One possible reason for this is differences in the percentage of locations where fire alarms were required to be installed.

Fire alarms in both hotels and hospitals were required mainly for locations with floor space of 300 m\(^2\) or more. As of 1970 approximately 40% of hotels had fire alarms, while only 15% of hospitals did\(^\text{Note10}\), the gap being due to differences in the size of common medical facilities and accommodation facilities. In any case, a 40% adoption rate (the fraction of buildings conforming with the regulations for fire alarms in hotels) is not large enough to explain the sudden decrease in average fire burned area, so there must be some factor other than retroactive application of regulations.

5.3 Ratios of Buildings with Fire Protection and Alarm Systems Installed

Japanese regulations for installing fire protection and alarm systems depend on many factors, such as building usage, total floor space, number of floors, floor space per floor, floor usage, the size of windows, whether floors are underground, and how high they are [r13].

To investigate whether retroactive application of requirements for fire protection and alarm systems (fire alarms in particular) was a primary reason for the sudden reduction in average fire burned area, it would be advantageous to know the installation ratios of fire alarms and sprinklers by usage, as per Section 5.2. Obtaining this information is difficult, however. Fire Services White Papers provide information related to the number of installations [13] and buildings [14] with such equipment, but the building count is only for buildings with floor space of 150 m\(^2\) or more, which creates significant deviations for counts of buildings of some usage types.

For example, Table 5 shows the number of buildings by usage with floor space of 150 m\(^2\) or more, the number of buildings in which fire alarms or sprinklers are installed, and floor space standards for installation.

\(^{\text{Note10}}\) Numbers for hotels were calculated as the ratio between the number of locations with total floor space of 150 m\(^2\) or more (78,793 locations nationwide, 10,758 in the 10 largest cities) and the number of fire alarm installations in the 10 largest cities (5,928), the above data being taken from the 1976 Fire Services White Paper, and the total national number (109,338). Numbers for hospitals were calculated as the ratio between the number of locations with total floor space of 150 m\(^2\) or more (45,495 locations nationwide, 10,173 in the 10 largest cities) and the number of fire alarm installations in the ten largest cities (3,975), the above data being taken from the 1976 Fire Services White Paper, and the total national number (113,973, from the 1976 Annual Report on Health and Welfare).
Table 5  Number of buildings by usage with floor space exceeding 150 m$^2$ and fire alarms or sprinklers (2011.3.31)

| Usage                              | Buildings with total floor space of 150 m$^2$ or more | Buildings with fire alarms | Buildings with sprinklers |
|------------------------------------|------------------------------------------------------|----------------------------|----------------------------|
|                                    | Floor space standards for installation (m$^2$)       | Number of buildings       | Floor space standards for installation (m$^2$) | Number of buildings |
| Designated use buildings           |                                                      |                            |                            |                        |
| Theater, Auditorium, etc.          | 70,415                                               | 300                        | 34,253                     | 6,000                  | 1,318                   |
| Bar, Adult entertainment, etc.     | 15,998                                               | 300                        | 13,865                     | 6,000                  | 670                      |
| Restaurant, etc.                   | 86,256                                               | 300                        | 36,993                     | 6,000                  | 122                      |
| Retail stores, etc.                | 149,347                                              | 300                        | 85,945                     | 3,000                  | 6,846                     |
| Hotel, Inn, etc.                   | 63,864                                               | 300                        | 48,554                     | 6,000                  | 1,990                     |
| Hospital, Clinic, etc.             | 63,726                                               | 300                        | 41,202                     | 3,000                  | 6,579                     |
| Nursing home, etc.                 | 32,299                                               | all                        | 30,707                     | 275                    | 21,014                    |
| Day nursery, etc.                  | 57,276                                               | 300                        | 41,666                     | 6,000                  | 1,052                     |
| Infant school                      | 18,779                                               | 300                        | 16,138                     | 6,000                  | 152                      |
| Sauna, Steam bathhouse, etc.       | 1,669                                                | 200                        | 1,532                      | 6,000                  | 19                       |
| Underground mall, etc.             | 75                                                   | 300                        | 74                         | 1,000                  | 70                       |
| Multipurpose buildings with designated use | 355,800                                           | 300                        | 171,803                    | 3,000                  | 12,729                    |
| Buildings other than designated use buildings |                                        |                            |                            |                        |                          |
| Apartment                          | 1,224,743                                             | 500                        | No data published         | No data published     | No data published        |
| School                             | 129,703                                              | 500                        |                            |                        |                          |
| Library, Museum, etc.              | 7,354                                                | 500                        |                            |                        |                          |
| Public bath                        | 5,658                                                | 500                        |                            |                        |                          |
| Station                            | 3,941                                                | 500                        |                            |                        |                          |
| Temple, Shrine, etc.               | 54,706                                               | 500                        |                            |                        |                          |
| Factory                            | 508,750                                              | 1,000                      |                            |                        |                          |
| Studio                             | 401                                                  | 500                        |                            |                        |                          |
| Parking house, etc.                | 50,527                                               | 500                        |                            |                        |                          |
| Warehouse                          | 324,528                                              | 500                        |                            |                        |                          |
| Office, etc.                       | 437,776                                              | 1,000                      |                            |                        |                          |
| Multipurpose buildings without designated use | 239,557                                           | 500                        |                            |                        |                          |
| National heritage buildings        | 8,703                                                | all                        |                            |                        |                          |
| Others                             | 1,427                                                |                            |                            |                        |                          |
| Total                              | 3,913,278                                            | 522,732                    |                            |                        | 52,561                    |

(Source: Fire Services White Paper 2012)
It is possible to obtain information about building counts by usage for those that require legal approval as in Section 5.2, but it is more difficult to obtain information about building counts where installation is not mandatory. Thus, calculating the percentage of buildings with fire protection and alarm systems installed for all usage types is difficult.

5.4 Effects of Large Fires

As shown in the data from “112 Case Studies of Fires,” some fires were of sufficiently large scale for one case to affect that year’s total fire burned area for the entire nation. Figures 10 and 11 therefore respectively show total fire burned area data from the Annual Fire Report for fires in fire-resistive hotels and retail stores, but with fires from “112 Case Studies of Fires” with a fire burned area exceeding 500 m$^2$ omitted$^{Note11}$.

Note11) According to the Annual Fire Report, the fire burned area in hotels that were fire-resistive buildings was 574 m$^2$ in 1975, but according to “112 Case Studies of Fires” the fire burned area of the Senjo Hotel in that year was 1501 m$^2$, alone exceeding the reported total. This discrepancy is likely due to some miscalculation; nonetheless, the Senjo Hotel fire was omitted from the calculation of large-scale fires.

Figure 10  Fire burned area for hotels with fire-resistive construction, comparing fires with fire burned area less than 500 m$^2$ and those with more.

(Source: Annual Fire Report and “112 Case Studies of Fires”)
These graphs suggest that retroactive application of fire alarms had a significant effect on reducing large-scale fires, which in turn contributed to the rapid decline in average fire burned area.

Note, however, that except for the case of the 1973 Taiyo Department Store fire, each of the 5 hotels and 11 stores that experienced large-scale fires had fire alarms installed, so simply installing fire alarms is not a sufficient measure to prevent large-scale fires. Still, retroactive application of regulations requiring the installation of fire alarms in all hotels and retail stores with floor space exceeding 300 m² reduced the risk of large fires, and that in combination with other fire-prevention measures likely had the intended effect. Such considerations may be sufficient to explain the problem brought up in Section 5.2, how effects were attained even with a fire alarm installation rate of only 40% in hotels.

Retroactive application of regulations for installation of all fire protection and alarm systems in designated use buildings took place in 1979 (1977 for retail stores and multipurpose buildings), so from that point on all designated use buildings with floor space exceeding 6000 m² would have sprinklers, an extremely effective measure for reducing fire burned areas.
None of the 70 fire buildings described in “112 Case Studies of Fires” and occurring in 1968 or later had sprinklers installed, but there were 24 building fires from 1979 onward at locations that should have had sprinklers.

Figure 12 shows the average fire burned area by building usage for fire-resistive buildings from 1968 to 2008. This graph shows that the average fire burned area for nonresidential buildings other than designated use buildings was approximately the same as designated use buildings until around 1990, but following that the figure often increased. The main reason for them was several increases in the fire burned areas of schools, factories, warehouses, and the like, building types for which there was no requirement for installing sprinklers, regardless of size. This means that if the initial handling of fires is not performed appropriately, a large-scale fire could easily result.

Figure 12  Average fire burned area in fire-resistive buildings by building use (1968–2008)

The above indicates that the rapid decline in average fire burned area in fire-resistive buildings seen from around 1970 to 1975 comes largely from sudden reduction of large-scale fires by the retroactive application of regulations for fire alarms, and from 1979 onward, further effects were seen due to retroactive application of regulations for sprinkler installations.

5.5  Effects that Reduce the Scale of Individual Fires

In addition to preventing large-scale fires, it is possible that amendments to fire-related rules and regulations had the additional effect of gradually reducing the overall scale of individual fires, thus contributing to a lowering of the average fire burned area. Further investigation of this possibility requires a consideration of the changes in average fire burned area for buildings other than designated use buildings.
(1) The effects of fire alarms

Since the 1960 amendments to the Fire Code, there have been nationwide, uniform requirements for fire alarms in buildings of a certain size or usage. Many buildings built before 1960, however, did not have fire alarms. The fraction of buildings conforming with the regulations of such systems gradually increased as new buildings were built and older buildings underwent extensive repairs or renovations. This is one possible reason why the average fire burned area for nonresidential buildings other than designated use buildings fell to less than one half the levels seen between 1970 and 1976 (Figure 7-3).

Most fire-resistant residential buildings are apartment buildings, for which alarm systems were required in buildings exceeding 500 m$^2$. At the time, fire departments could issue exemptions from rules requiring fire alarms in cases of apartments with floor space of 70 m$^2$ or less that featured fire-resistant construction, and had high-performance fire control features between units and in halls and stairways. As a result, most apartment buildings did not have fire alarms, and this may be why there was a trend toward reduced fire burned area in nonresidential buildings other than designated fire prevention buildings, but that trend was not seen in fire-resistant residential buildings (Figure 7-3).

(2) The effects of incombustible and flame retardant interior materials

The two areas of the Japanese Building Code that have a direct relationship with reducing fire burned areas are restrictions on interior materials and fire compartment. A number of revisions to regulations concerning interior materials were implemented between 1964 and 1974, as listed in Table 6.
Restrictions on interior materials in Order for Enforcement of Building Code (article 129) were first regulated in 1959, and revised several times (Table 6). Therefore the effect of early revisions might be reflected in fire statistics.

Figure 13 shows manufacturing volumes of gypsum board, one of the primary materials used for building interiors now. The graph shows that gypsum board production volumes increased approximately two and half a times between 1964 and 1974, seemingly in sync with increased restrictions on interior materials. Supposing that increasingly tighter restrictions on interior materials was a factor in the rapid increase in gypsum board production volumes, this might be an explanation for why the fire burned area of buildings to which fire protection and alarm systems standards were not retroactively applied nonetheless fell between 1970 and 1976 to less than one half of previous values. However, an inconsistent observation is that a considerable amount of the gypsum board manufactured at the time would have been used in houses, yet there is no visible trend toward reduced average fire burned area in fire-resistant residential buildings.

| Year enacted | Clause | Description |
|--------------|--------|-------------|
| 1964         | Article 112, Item 5–Item 7 | Set fire partition sizes on 11th floor or higher at 100 m\(^2\) or less, with provision for expansion to 200 m\(^2\) or 500 m\(^2\) given sufficient fireproofing of interior materials. |
|              | Article 120, Item 2, Item 3 | Set fire partition sizes on 11th floor or higher at 100 m\(^2\) or less, with provision for expansion to 200 m\(^2\) or 500 m\(^2\) given sufficient fireproofing of interior materials. |
|              | Article 123, Item 3, Paragraph 2 | Set out details related to the non-combustibility of interiors in special evacuation stairways and terminal rooms. |
|              | Article 129, Item 4 | Added restrictions on interiors of rooms and emergency routes in buildings exceeding 31 m in height. |
| 1969         | Article 128-4, Item 1, Paragraph 1 | Expanded application of rules concerning interiors to hotels, hospitals, and apartments three stories or higher and with floor space of 300 m\(^2\) or more. |
|              | Article 129, Item 1, Item 2, Item 4 | Strengthened law, excluding flame retardant materials from the hallways and stairs of special buildings and high-rise buildings. |
| 1971         | Article 111; Article 116-2; Article 128-3-2; Article 144-4 | Established definition of “windowless room” and calculation methods to strengthen laws by adding requirements for fire-resistant construction of main structural components that compartmentalize rooms (Article 111); require smoke control systems (Article 116-2), and places limits on interiors (Article 128-3-2). |
|              | Article 128-3-2 through Article 129 | Strengthened restrictions on special building interiors, etc. |
| 1974         | Article 129 | Strengthened limits on interiors by requiring that ceiling finishes in high-rise special buildings be created from semi-noncombustible materials or better. |
6. CONCLUSIONS

This paper presented the causes for the sudden decrease in fire damage to large buildings from about 1970 to 1980 by comparing fire statistics with the content of revisions to fire regulations and retroactive application to existing buildings.

The results of this study are summarized as follows:

1) Retroactive application of regulations resulted in the installation of fire alarms in all designated use buildings of a certain size, which in turn lowered the risk of large-scale fires. Therefore the number of incidences of large-scale fires rapidly fell, perhaps due in part to synergistic effects with other fire prevention measures.

2) Retroactive application of regulations pertaining to sprinklers played a major role in preventing large-scale fires from 1979 and beyond, but was not related to the rapid decline in average fire burned area seen between 1970 and 1975.

3) Even in buildings that were not the target of retroactive application of regulations pertaining to fire protection and alarm systems, the application of regulations related to the installation of fire alarms and restrictions on interiors to increasingly many buildings, along with increasing widespread use of gypsum board, played a role in reducing fire burned areas.
4) While there is a possibility that other fire regulations, such as requirements for fire compartments and indoor fire hydrants, have played a role in reducing average fire burned area, such effects were not identified.

APPENDIX 1

Main Revision of Order for Enforcement of the Building Code pertaining to fire prevention and safety (1964–1974)

| Measures                        | Year of enactment | Amendment (as per amended document) | Description                                                                                                                                 |
|---------------------------------|-------------------|--------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Fire compartment                |                   |                                      | Set fire compartments in buildings over 10 stories at 100 m² or less, with allowances for 200 or 500 m² compartments with non-flammable interiors |
|                                 | 1964              | Article 112, Item 5–Item 7            |                                                                                                                                           |
|                                 | 1969              | Article 112, Item 9                  | Newly established pit compartment                                                                                                        |
|                                 | 1969              | Article 112, Item 13; Article 113, Item 1, Paragraph 4 | Set requirements for automatic closing of fire compartment fire doors during emergencies, etc.                                              |
|                                 | 1974              | Article 112, Item 14                 | Newly established requirements for fire doors that remain shut between fire compartments, and furthermore required that fire doors used in pit compartments and compartments for other purposes be of a type that remains closed, or has a smoke detection system with smoke blockage features that activate upon detection of smoke |
| Restrictions on interior materials | 1964              | Article 129, Item 4                  | Placed limits on interior of evacuation routes and occupied rooms in buildings exceeding 31 m in height                                   |
|                                 | 1969              | Article 128-4, Item 1, Paragraph 1   | Expanded application of regulations for interiors to hotels, hospitals, and apartments exceeding 2 stories and 300 m²                      |
|                                 | 1971              | Article 128-3-2; though Article 129 | Strengthened restrictions on interior decoration for special buildings, etc.                                                              |
|                                 | 1974              | Article 129                        | Strengthened restrictions on interiors by requiring finishing of ceilings in special high-rise buildings to be at least semi-noncombustible |
| Evacuation facilities           | 1964              | Article 120, Item 2, Item 3          | For 15th floors and above, set permissible walking distances to direct access stairs according to the amount of non-flammable material used in occupied rooms |
|                                 | 1969              | Article 121, Item 3                 | Set requirements for dual-directional evacuation when 2 or more direct stairways are available                                           |
|                                 | 1971              | Article 126-2; Article 126-3         | Established new standards pertaining to the installation and construction of smoke control systems                                           |
| Facilities for fire-fighters    | 1971              | Article 129-13-2; though Article 129-13-3 | Established new standards pertaining to the installation and construction of emergency elevators                                              |
## APPENDIX 2

Main revision of Fire Code and Order for Enforcement (1964–1974)

| Measures                  | Year of enactment | Amendment (as per amended document) | Description                                                                                                                                 |
|---------------------------|-------------------|-------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------|
| Sprinkler systems        | 1964              | Article 12                          | Set forth requirements for sprinkler systems to be installed on the floor 11 and higher of special-purpose buildings, and established installation standards (However, sprinklers are not required if smaller (100-500 m²) fire compartment is employed.) |
|                           | 1972              | Article 12, Item 1, Paragraph 2     | Expands requirements for sprinkler system installation to special fire prevention buildings with over 6000 m² total floor space (previous requirements for department stores were for 9000 m² for stores with 4 floors or less, 6000 m² for those with 5 floors or more) |
|                           | 1974              | Article 12, Item 1, Paragraph 5     | Requires the installation of sprinkler systems in multipurpose buildings that contain special fire prevention designated usage with total floor space over 3000 m² on the floor that contains the section in question |
|                           | 1974              | Article 12, Item 1, Paragraph 6     | Expands (for theaters, restaurants, special bathing facilities, and multipurpose units) and strengthens (for restaurants, hotels, and hospitals, etc.) requirements for sprinkler systems in basements, windowless floors, and 4th–10th floors with floor space of 100–1500 m² |
| Emergency alarm systems  | 1969              | Article 24                          | Strengthened installation and equipment standards for emergency alarm systems in large buildings (hotels and hospitals with capacity exceeding 300 persons, or other building usage types that might pose risk) |
|                           | 1972              | Article 24                          | Expanded the scope of requirements for installing emergency alarm systems in department stores, and expanded the scope of emergency alarms for installation in inns, hotels, hospitals, special bathing facilities, and multipurpose buildings. |
| Retroactive application | 1966 | Article 34, Paragraph 2 | Added fire alarms to the list of equipment for which retroactive application is required in buildings of cultural significance |
|-------------------------|------|-------------------------|----------------------------------------------------------------------------------------------------------------------------------|
|                        | 1969 | Article 34, Paragraph 2 | Added inns, hotels, and hospitals as buildings requiring retroactive application of standards for alarm systems |
|                        | 1972 | Article 34, Paragraph 2 | Expands retroactive application of requirements for alarm systems from “inns, hotels, and hospitals” to “buildings with uses that could result in extensive loss of human life in the event of a fire” (buildings subject to specific fire protection) |
|                        | 1974 | Article 17-2, Item 2; Paragraph 6; Article 17-3, Item 2; Paragraph 4 | Retroactive application of technical standards for installation and maintenance of fire prevention equipment in buildings subject to specific fire protection |
| Others                 | 1964 | Article 26, Item 1      | Set requirements for guidance lamps and signage in buildings exceeding 10 floors |
|                        |      | Article 27, Item 1      | Required water supply for firefighting in large buildings exceeding 31 m |
|                        |      | Article 29              | Established and strengthened requirements for coupled water system pipes and pressurized delivery in buildings exceeding 70 m in height |
|                        |      | Article 29-2            | Required installation of emergency power outlets in buildings exceeding 10 floors |
|                        | 1968 | Article 8-1             | Expanded the role of fire prevention managers |
|                        |      | Article 8-2             | Established a system for joint fire protection management |
|                        |      | Article 8-3             | Established regulations about flame retardant |
|                        | 1972 | Article 1, Item 1       | Expanded the target for application of fire prevention management systems for buildings subject to specific fire protection from places holding over 50 people to those holding over 30 people for department stores, underground malls, multipurpose buildings, inns, hospitals, and other locations that pose a risk for extensive loss of life in the event of a fire. |
|                        |      | Article 3               | Strengthening qualifications and responsibilities of fire prevention manager |
|                        |      | Article 28-2            | Required installation of and sets technical standards for consolidated sprinkler systems in buildings with a 700 m² or larger basement. |
|                        | 1974 | Article 17-3-2          | System for inspection of fire prevention equipment by fire chief at time of installation |
|                        |      | Article 17-3-3          | System for periodic inspection of fire prevention equipment by licensed inspector, and system for notification to fire chief |
|                        |      | Article 9-2             | Comprehensive regulation of sprinkler systems, fire alarms, and emergency alarm systems for buildings with basements forming part of an underground mall |
|                        |      | Article 29-3            | Requirements for installing wireless communications antennas in underground malls exceeding 1000 m² floor space |
APPENDIX 3

Comparison of usage categories between Annual Fire Report usage classifications and classification by the Order for Enforcement of the Fire Code, Supplemental Table 1

| Annual Fire Report usage classifications | Classification by the Order for Enforcement of the Fire Code, Supplemental Table 1 | Annual Fire Report usage classifications |
|-----------------------------------------|------------------------------------------------------------------------------------|-----------------------------------------|
| Restaurants                             | Item (3)                                                                            | Factories or assembly plants            |
| Department stores, markets              | Item (4)                                                                            | Warehouses                              |
| Other stores                            | Item (4)                                                                            | Garages                                 |
| Inns, hotels, and lodging places        | Item (5)a                                                                           | Livestock pens                          |
| Live theaters, movie theaters, and other entertainment venues | Item (1)a                                                                           | Schools                                 |
| Hospitals and clinics                   | Item (6)a                                                                           | Government offices                      |
| Social welfare facilities               | Item (6)b                                                                           | Shrines, temples, and churches          |
| Dwellings                               | No category for houses; apartments classified as Item (5)b                         | Bathing facilities                      |
| Offices                                 | Item (15)                                                                           | Other special buildings                 |
|                                        |                                                                                    | Associated buildings                    |

REFERENCES (RESEARCH PAPERS)

1. H. Murai, K. Shida, K. Suzuki, H. Kurioka and H. Sato, Proposed distribution characteristics of burn damage area—Statistical analysis on the effect of suppressing fire damage through fire protection measures—Part 1, Summaries of Technical Papers of the Annual Meeting of the Architectural Institute of Japan (Tokai), 199–200, 2003.
2. K. Shida, H. Murai, K. Suzuki, H. Kurioka and H. Sato, Factor analysis of the effects of daily maintenance and fire protection and alarm systems installations on the distribution characteristics of fire burned area—Statistical analysis on the effect of suppressing fire damage through fire protection measures—Part 1, Summaries of Technical Papers of the Annual Meeting of the Architectural Institute of Japan (Tokai), 201-202, 2003.

3. K. Suzuki, H. Murai, H. Kurioka, H. Sato and K. Shida, Factor analysis of the effects of daily maintenance and fire protection and alarm systems installations on the distribution characteristics of fire burned area—Statistical analysis on the effect of suppressing fire damage through fire protection measures—Part 2, Abstracts of the 2003 Conference of the Japan Association for Fire Science and Engineering, 340-343, 2003.

4. K. Suzuki, Expected value of building fire loss with a focus on industrial classification, Summaries of Technical Papers of the Annual Meeting of the Architectural Institute of Japan (Tokai), 203–204, 2003.

5. H. Sato, H. Kurioka, K. Shida and H. Murai, A study on burn damage areas and ratios in offices and factories (Part 1), Summaries of Technical Papers of the Annual Meeting of the Architectural Institute of Japan (Chugoku), 91-92, 2008.

6. H. Kurioka, H. Sato, K. Shida and H. Murai, A study on burn damage areas and ratios in offices and factories (Part 2), Summaries of Technical Papers of the Annual Meeting of the Architectural Institute of Japan (Chugoku), 93-94, 2008.

7. D. Nii and I. Hagiwara, Study on the risk of fire expansion in buildings, Summaries of Technical Papers of the Annual Meeting of the Architectural Institute of Japan (Chugoku), pp. 99–100, 2008.

8. A. Sekizawa and S. Horiuchi, Calculation guidelines for calculating burn damage areas, Fire Report Vol. 27, No. 1(106), 42–46, 1977.

9. Fire and Disaster Management Agency, Fire damage since 1946, the 2010 Fire Service White Paper, 282, 2010.

10. Fire and Disaster Management Agency, Number of firefighting organizations and firefighters, the 2010 Fire Service White Paper, 301, 2010; and Fire and Disaster Management Agency, Number of firefighting organizations, firefighters, and firefighting personnel, the 1959 Current state of fires and fire prevention, 55, 1959.

11. Fire and Disaster Management Agency, Record of conflagrations since 1946, the 2010 Fire Service White Paper, 284, 2010.

12. Fire Defense Council and Building Council, Status of fire prevention measures in high-rise buildings and underground malls, Fire Defense Council Report and Building Council Report,1967

13. Fire and Disaster Management Agency, Nationwide status of sprinkler system and fire alarm installations in designated use buildings, the 2011 Fire Services White Paper, 89, 2011

14. Fire and Disaster Management Agency, Number of buildings designated for fire prevention, the 2011 Fire Services White Paper, 84, 2011
REFERENCES (REGULATORY DOCUMENTS)

r1. Building Standards Law, Article 3.
r2. Fire Code, Article 17-2-5.
r3. Fire Code, Article 17-2-5, Item 1.
r4. Order for Enforcement of Fire Code, Article 34, Paragraph 2 due to Cabinet Order No. 379 in 1966.
r5. Order for Enforcement of Fire Code, Article 34, Paragraph 2 due to Cabinet Order No. 18 in 1966.
r6. Order for Enforcement of Fire Code, Article 34, Paragraph 2 due to Cabinet Order No. 411 in 1972.
r7. Fire Code, Article 17-2-5, Item 2, Paragraph 4.
r8. Fire Code, Article 31 through 35-4.
r9. Building Code, Article 27
r10. Building Standard Division Chief of Ministry of Construction, Interpretation of partial structural differences in buildings, Housing Disaster Memorandum 14, dated 6 March 1951.
r11. Fire Code, Article 8, Item 1, as amended by Act No. 64, 1 June 1974.
r12. Fire Prevention Division Chief and Fire Safety Division Chief of Fire and Disaster Management Agency, Handling of buildings listed in Supplemental Table 1, Fire Prevention Directive 41 and Fire Safety Directive 41, dated 15 Apr 1975
r13. Order for Enforcement of Fire Code, Article 10 through 29-3.
r14. Order for Enforcement of Fire Code, Article 21, Item 1, Paragraph 4.
r15. Deputy Director of Fire and Disaster Management Agency, Handling of apartment buildings after partial revision of Fire Code, Notification No118, dated 1 Aug 19