■ Research Paper ■

Effects of Fire Regulation Revisions on Building Fire Damage

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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

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1. INTRODUCTION

The Japanese Annual Fire Report[Note1)] indicates that the yearly average area of floor space experiencing fire damage[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

Note[1)] 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.

Note[2)] 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.

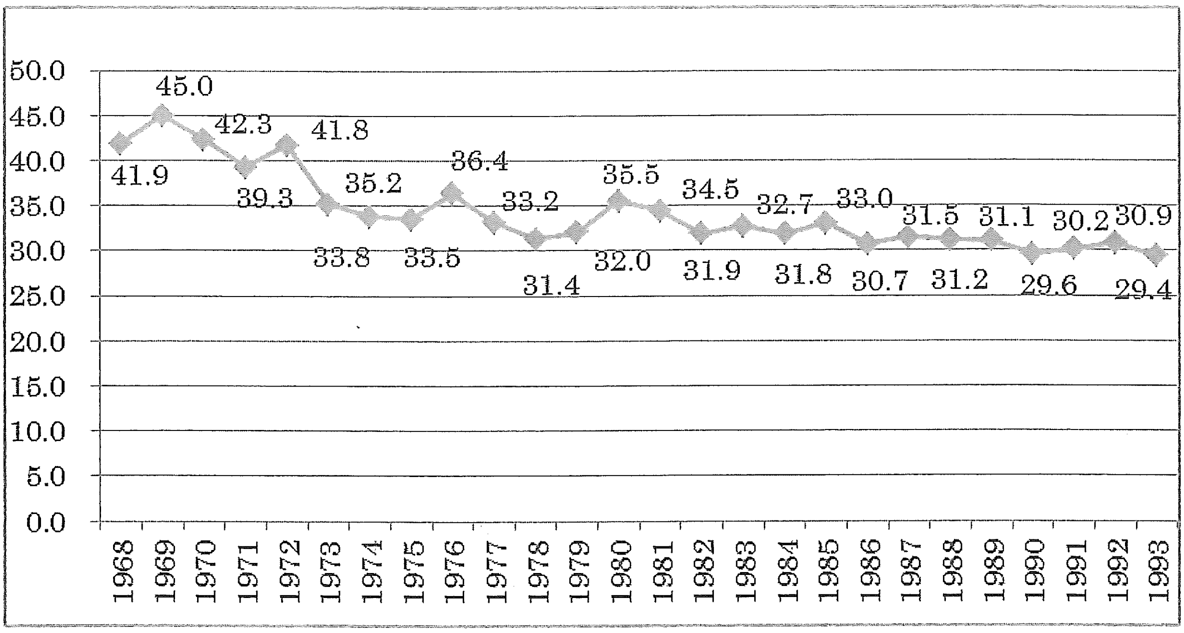

Figure 1 Average fire burned area (m^2) for building fires (1968–1993)

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[Note3)] 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.

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).

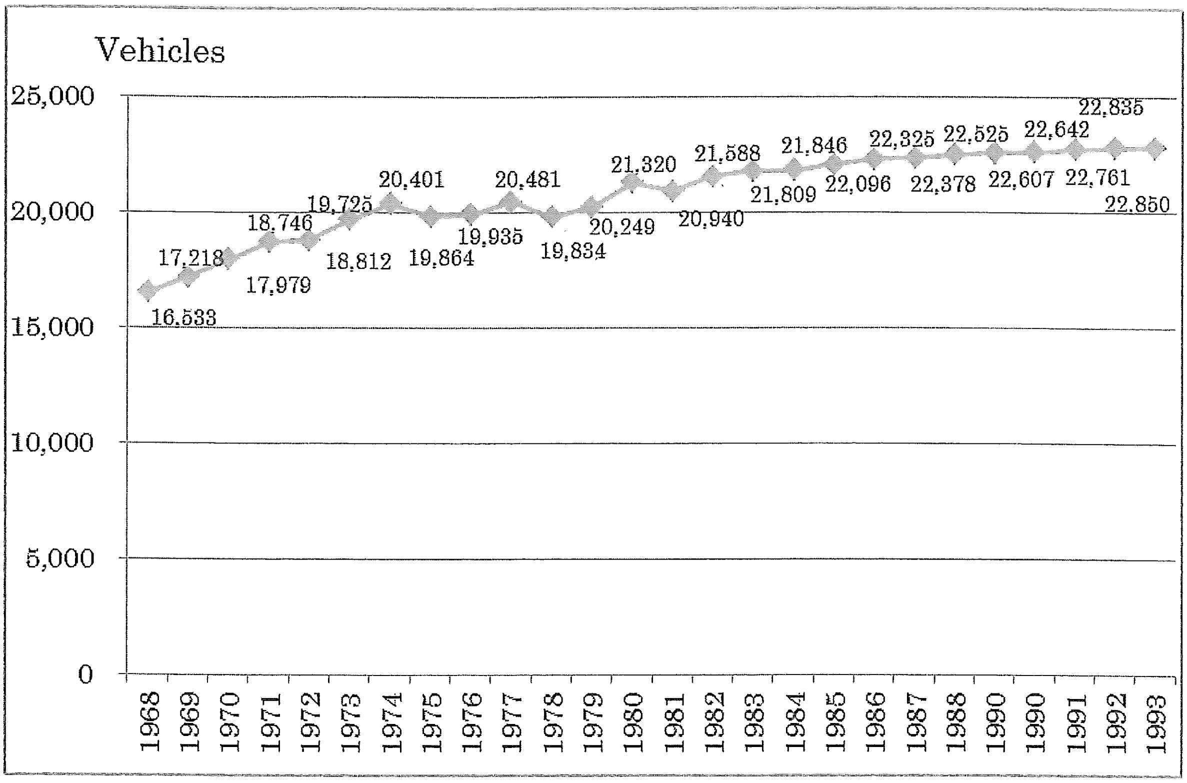

Figure 2 Number of fire engines with pumps (1968–1993)
(Source: Fire Services White Paper[11]*)*

Conflagrations[Note4)] often occurred before the 1970s in Japan (*Figure 3*), and affected the average fire burned area of buildings. Conflagrations were rare after the 1970s.

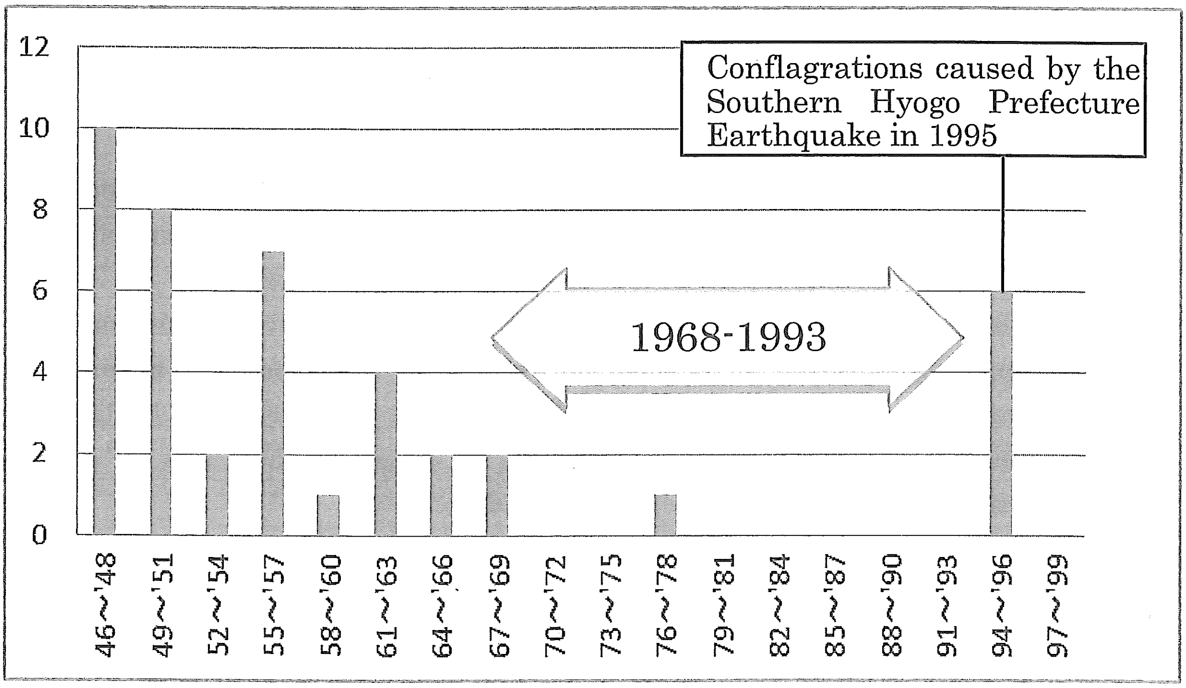

Figure 3 Conflagrations in Japan (1946–1999)
(Source: Fire Services White Paper[11]*)*

Note[4)] Appendix II-8 in the 2011 Fire Service White Paper defines conflagrations as fires exceeding 33,000 m^2 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 m^2 to approximately 50 m^2.
2) The average fire burned area of wood construction buildings fell by approximately 12.5% between 1968 (73.4 m^2) and 1975 (64.2 m^2).
3) The average fire burned area of fire preventive buildings showed a slight increase between 1968 and 1971 to an average 43.4 m^2, but then fell 28.8% to 30.9 m^2 in 1975 and remained roughly the same thereafter.
4) The average fire burned area of quasi-fire-resistive buildings remains approximately 64.7 m^2 between 1969 and 1980. That is followed by an extended period at approximately 57.6 m^2 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 m^2 to 41.0 m^2 between 1968 and 1970, but following that dropped 70% to 12.1 m^2 in 1976. Following that has been a general downward trend, despite sporadic increases, to a stable value of approximately 8–9 m^2 since 1984.

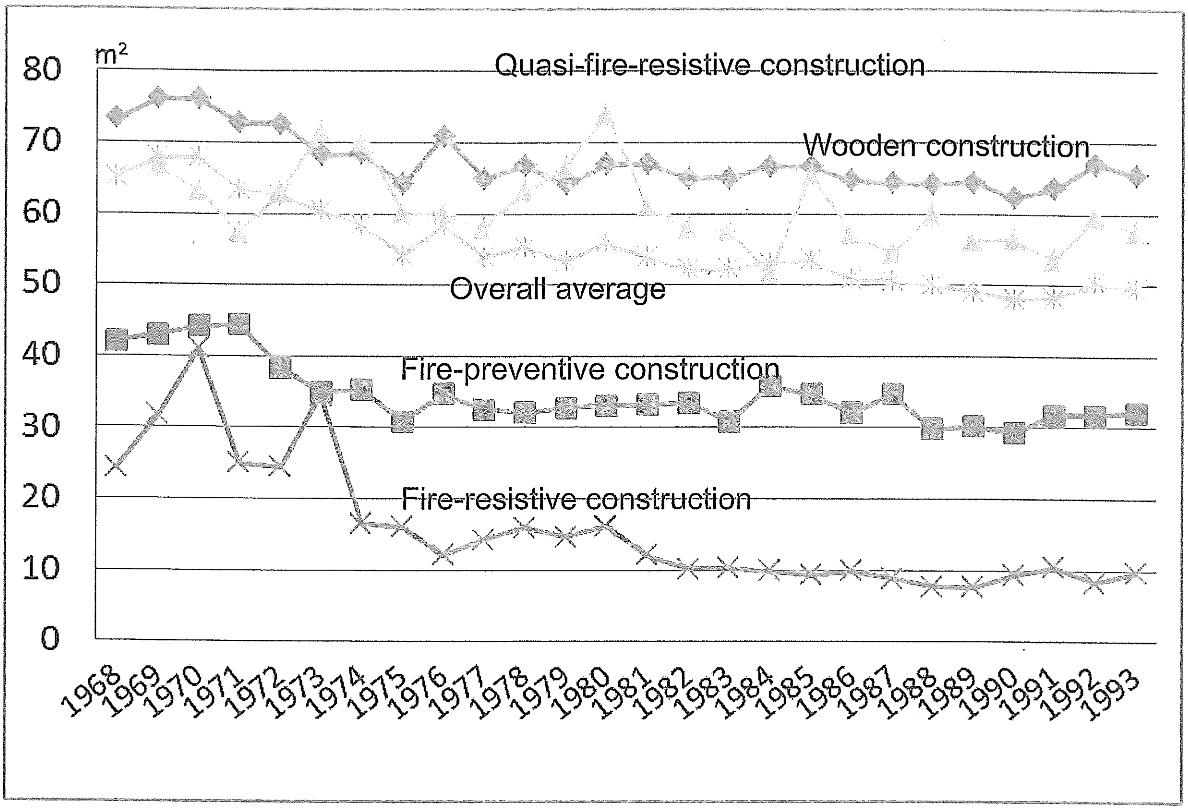

Figure 4 Average fire burned area by structure type (1968–1993)
(Source: Annual Fire Report)

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[Note5)]. This means that failure to control fires at the earliest stages often led to larger fire burned areas.

Note[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.

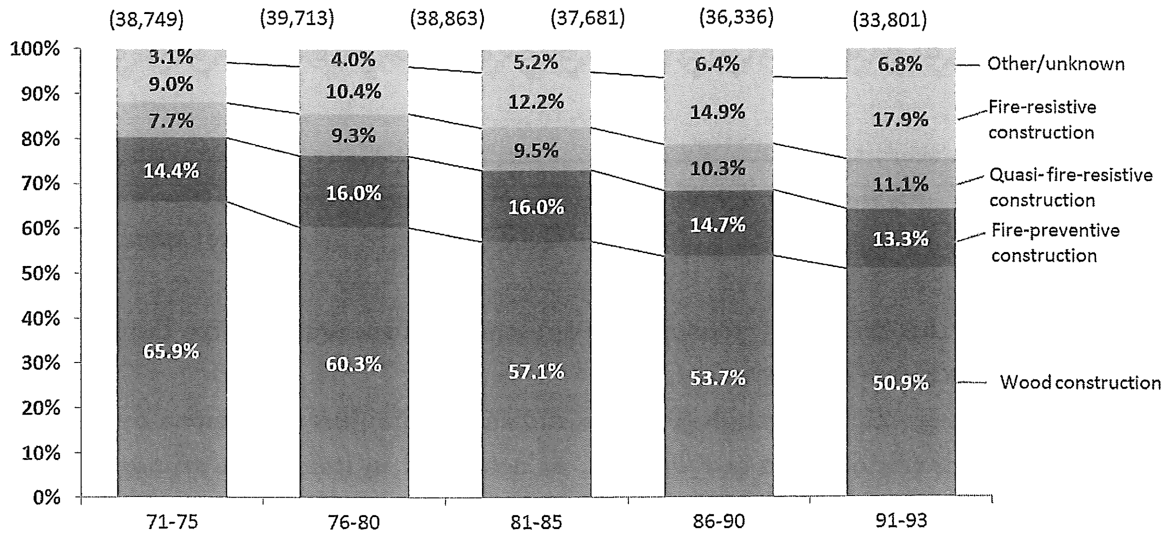

Figure 5 Ratios of building fires by structure type (1969–1993)
(Source: Annual Fire Report, "Building Fires by Fire Source Building Usage and Construction")

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
Feb1969	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[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[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.

Note[6)] pit compartment: fire compartment between every pit (staircase, escalator, elevator shaft, pipe shaft, atrium, and so on) and other parts in a building.

Note[7)] 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 lowing 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.

Table 3 Time limits for retroactive application of fire protection and alarm systems

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* [Note8].

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 m^2 or less (until 1975) or 100 m^2 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 m^2 or less (until 1987) or 200 m^2 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).

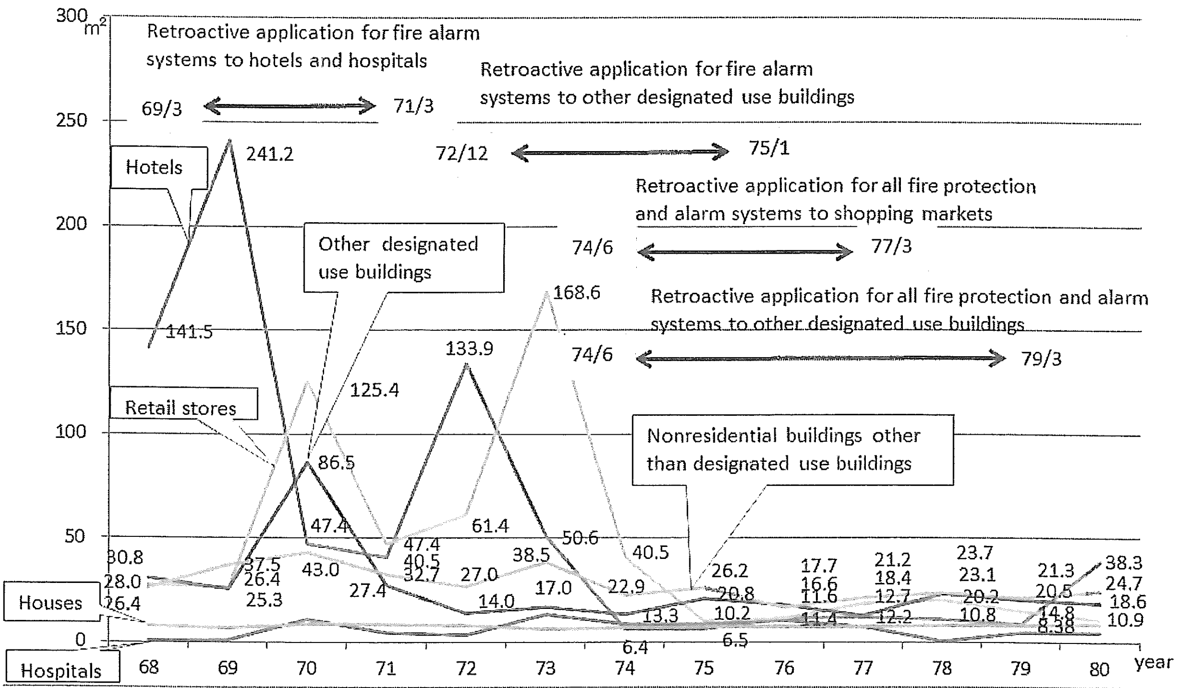

Figure 7 Average fire burned area in fire-resistive buildings by usage (1968-80)

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.

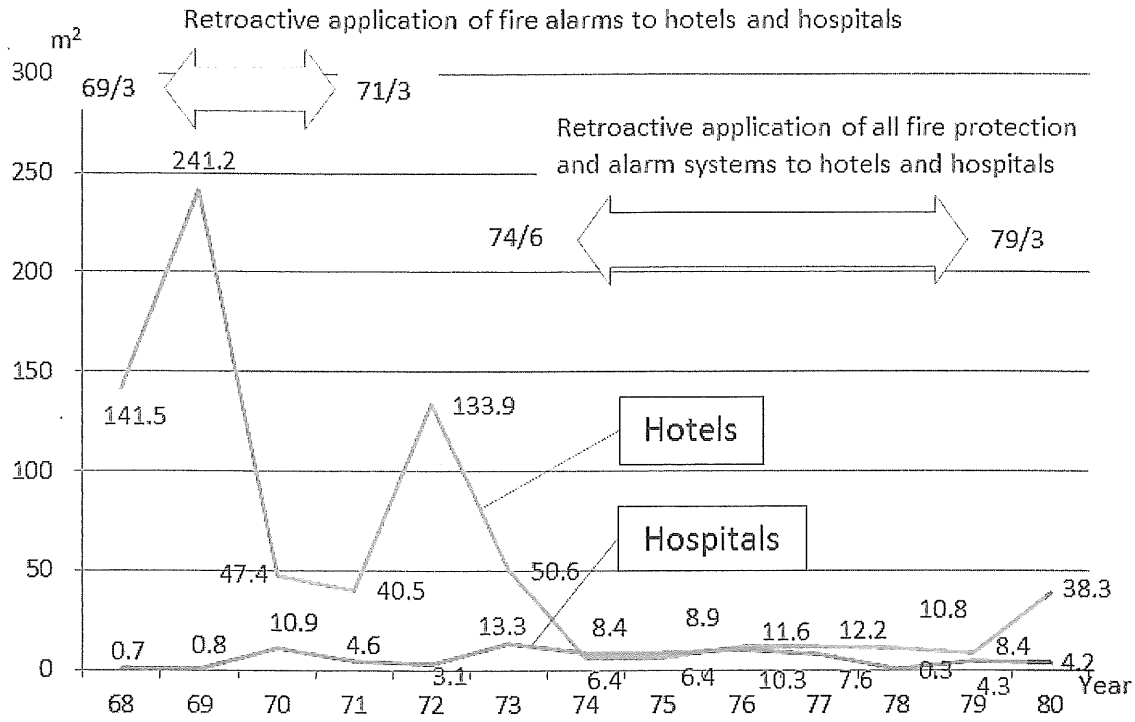

Figure 7-1 Average fire burned area in fire-resistive hotels and hospitals (1968-80)

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.

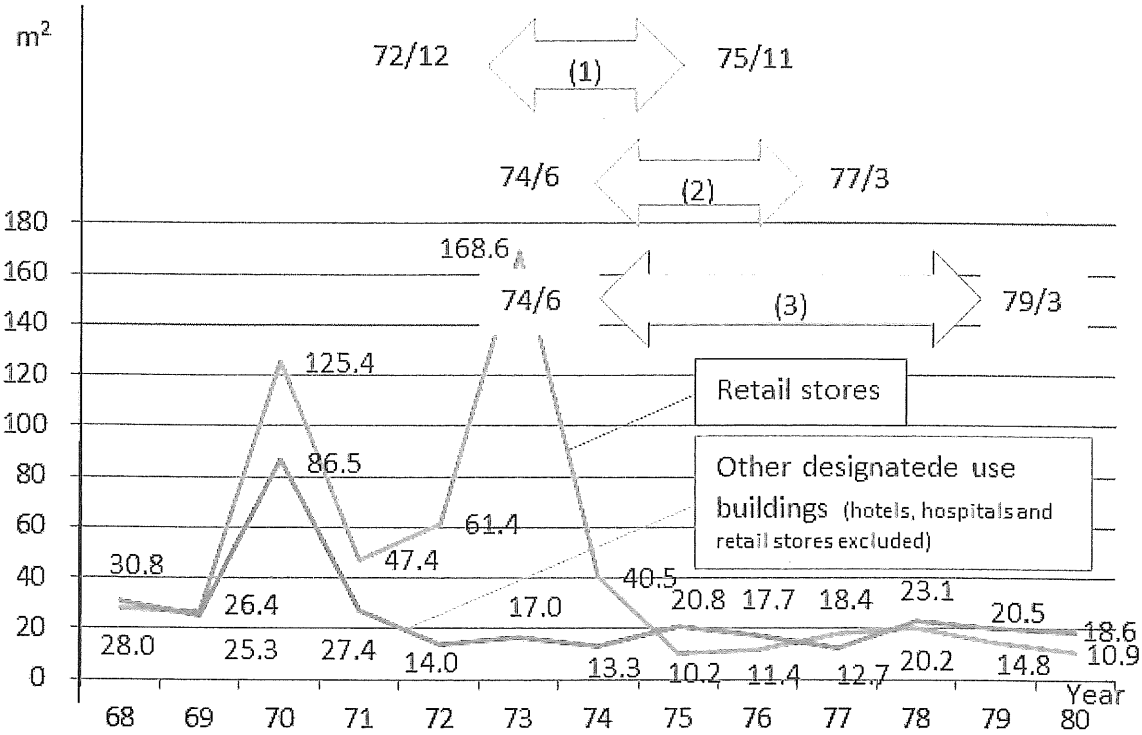

Figure 7-2 Average fire burned area in fire-resistive retail stores and other designated use buildings (1968–80)

(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).

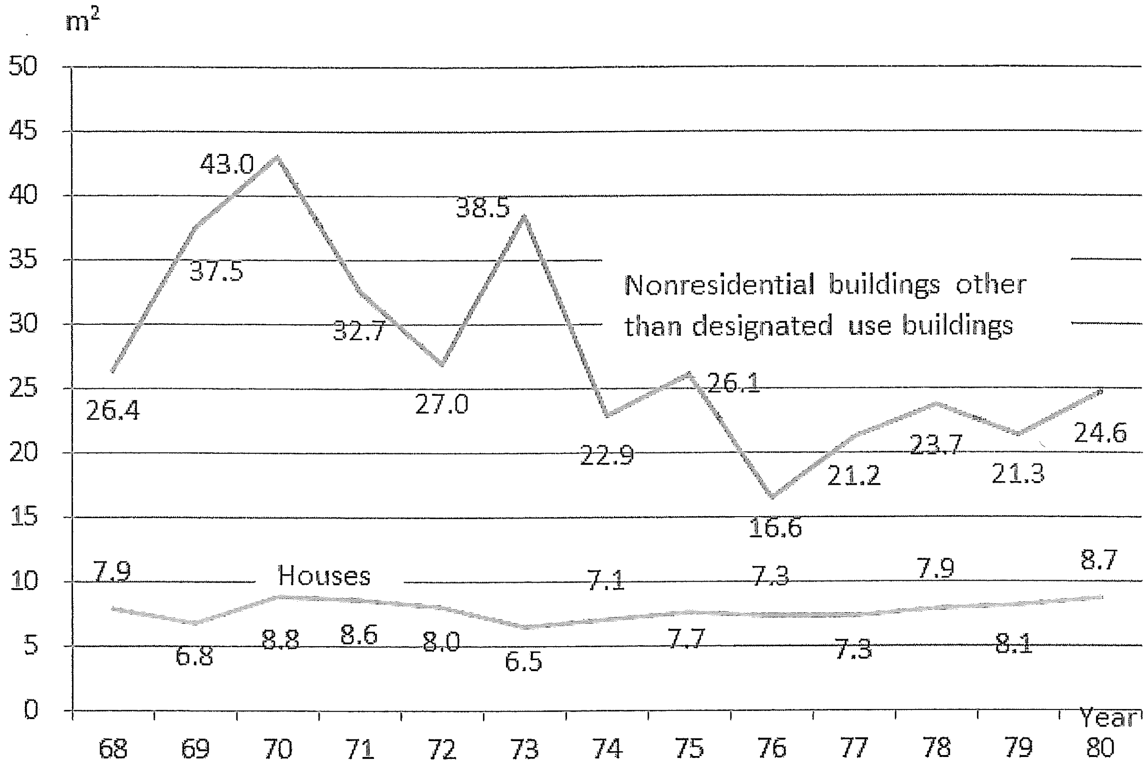

Figure 7-3 Average fire burned area in fire-resistive houses and nonresidential buildings other than designated use buildings (1968–80)

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.