6. ANALYSIS AND CONCLUSIONS

From the present experiments, the smoke movement characteristics in the Himeji-jo Castle Main Tower can be summarized as follows.

1) Significance of the dam-effect of the tall soffits
The soffits prevented, or at least, delayed considerably smoke penetration between the interior zone and the exterior corridors in all the tests conducted.
2) Significance of the influence of the layout of the stairs on smoke movement
Smoke tends to accumulate in an floor if the up-stairs are far away from the smoke conveying down-stairs.
3) Importance of the soffits on the second floor for the restriction of the smoke due to a fire on the lower floors
Because of the lack of a closed shaft, smoke in fire loses rapidly buoyancy to penetrate into upper stairs. On the other hand, once a few floors are involved by fire, the higher temperature in the tower than ambience and the windows open establish natural ventilation between the smoke-insulted floors and ambience. All these are believed to promote smoke flow out from the midst of the tower rather than that toward the top of the tower.
4) Importance of the open windows for the prevention of smoke penetration to upper floors
In this tower, there is no vertical shaft such as staircase or elevator to cause the chimney effect, and the open stairs are located far from each other. So, smoke loses its buoyancy as it goes up.
5) Fast vertical smoke spread on the fourth and the fifth floors
The fourth and the fifth floors are both composed of a relatively small single comportment with relatively small open windows, and the stairs are located relatively close to each other. Because of these features, decay of the buoyancy of upward smoke is believed to be weaker on these floors than on the lower floors. This effect is observed in some of the present tests.

The experiments are still continued at the submission of this report, and more detailed and quantitative measurements are to be carried out. Integration of these results with the evacuation characteristics of the building should be essential for the functional life safety planning of the castle. Special considerations on evacuation safety should be necessary for the following features of the castle.
1) Steep unprotected stairs
2) Large fraction of aged people in the visitors
3) Communication difficulty with foreign visitors

This study has been carried out as a part of the project on the fire safety planing of the Himeji-jo Castle Main Tower organized by the Fire Protection Equipment & Safety Center of Japan and funded by Himeji-City.

TERMINOLOGY

T :Temperature,Q : Heat release rate,To :Ambient temperature(25 ℃),t :Time, Cs : Extinction coefficient

Fire Problems and Fire Protection Management for Wooden Shrines and Temples in Japan

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ABSTRACT

This report clarifies special characteristics of fires in wooden buildings constructed by traditional methods, and problems in fire protection management. Data of past investigations are analyzed on fire protection management and fires in Japanese shrines and temples designated as cultural properties. The results of analysis show that the most common case of fires is arson carried out at night, and in many cases there was no one in the building when the fire occurred. Arsonists can enter shrine areas more easily than temple areas. On the other hand, in case of fire, neighbors' cooperation is obtained more often for shrines than for temples. Furthermore, it is clear that the percentage of temples that have a fire protection manager, a watch service, and an in-house emergency organization tends to be higher than that of shrines.

KEY WORDS: wooden buildings, fire protection management, fire cases, arson, cultural properties, shrine, temple

INTRODUCTION

For wooden buildings constructed using traditional Japanese methods, there is a strong probability of fire spreading to adjacent buildings before fire brigades arrive on the scene. Therefore, various codes have been established in Japan that regulate wooden buildings. In particular, building and rebuilding traditional wooden buildings over the size regulated in the Building Standard Law is restricted in urban areas designated as fire preventive districts or quasi-fire preventive districts. However, buildings of cultural properties designated as national treasure or important cultural properties are not bound by the Building Standard Law, so it is permissible to rebuild them on the same site.

Large percentage of shrines and temples elected on the land of Japan are traditional wooden buildings. Even in urban areas, there are many of these buildings. Some of them were built before the Building Standard Law was established in 1950. In Taito Ward in the Tokyo metropolitan area, there are 380 shrines and temples. However, few of these buildings are

designated as cultural properties. Some shrines and temples in urban areas such as Taito Ward are not of wooden construction because of building code restrictions, high construction cost, a decrease of available building sites caused by overpopulation, and a common understanding that "Wooden buildings burn easily".

On the other hand, it is permissible to build a wooden construction in fire preventive districts. If the special approval of the Minister of Construction based on Article 38 of the Building Standard Law is obtained, this can be realized by evaluating factors on fire safety such as surrounding building materials, fire detecting systems, fire extinguishing systems and fire prevention management. Yushima Shrine in Bunkyo Ward of Tokyo is one of those buildings. The question of what traditional wooden buildings such as shrines and temples should be in urban areas is an issure that ought to be discussed. Furthermore, a good building technique needs to be found for traditional Japanese wooden structures.

In this paper, we mention about newly comparative study of temples and shrines in Japan based on a series of investigation results [1] on cultural property buildings. It is focused on the difference between temples and shrines with respect to cause of fire, ignition point and actual fire protection management. The investigations that we referred to were conducted by a committee of the Fire Defense Agency of the Ministry of Home Affairs: "Investigation and Consideration on Promoting the Total Fire Protection Measures for Preservation of Cultural Property Buildings".

INVESTIGATION OUTLINE

Two kinds of investigation results were used for comparative study. We extracted data of temples and shrines from these results, and summed up each data respectively. Concerning about studies of cause of fire and ignition point, the total data including every building use were used. These investigations conducted in past are outlined as follows. Investigation results for everything except shrines and temples have already been reported by Naruse and others [2,3].

i) Investigation on cases of fire in cultural property buildings
110 fires in cultural properties were investigated by the fire department of each district in which these fire occurred. Items of 110 fires are fires that occurred after 1979 and were reported to the Fire Defense Agency, and fires that occurred after 1955 to 1978 and were reported to the Agency for Cultural Affairs. 90 fires among them were useful data. The investigated items were fire cause, fire origin, extent of damage, process of fire growth, ignition time, ignition season, fire protection management, whether or not the fire protection system worked, and fire fighting circumstances. The breakdown of these fire cases are shrines: 29.5%, temples: 34.7%, castles: 5.3%, residences: 15.8% and others: 14.8%.

ii) Investigation of fire protection management and fire protection systems for cultural property buildings
This investigation was conducted in the Tokyo metropolitan area, the city of Kyoto, Kobe, Kamakura, Kanazawa, and Ohtsu by each fire department in 1994. A total of 124 buildings of cultural properties were randomized from each city to avoid clustering in scale, condition of location, construction type, number of buildings and others. The investigated items were outlines of buildings and sites, fire protection management of building sites, installed fire protection system, and others. In order to compare the results from this investigation with the results of fire cases, the same formats were used. The investigated buildings were shrines: 24.0%, temples: 48.5%, castles: 1.2%, residences: 16.4%, and others: 9.9%.

CHARACTERISTICS OF FIRES OF SHRINES AND TEMPLES

Figure 1 shows fire causes for cultural property buildings. The most common fire cause is arson and the second is skyrockets. Skyrockets and the fire brands from bonfires commonly ignite roofs of vegetable materials such as cypress bark shingles and thatch. It is not necessary to consider these cases because almost all shrines and temples in urban areas use noncombustible material such as clay tiles and sheet copper for roofing. Figure 2 shows other fire causes for cases except where the ignition point was a roof of vegetable materials. As indicated, the rate of arson thus rises to almost half (48%). Furthermore, the total rate for arson, playing with fire and fireworks resulting from intrusion of people into building precincts reaches 55%.

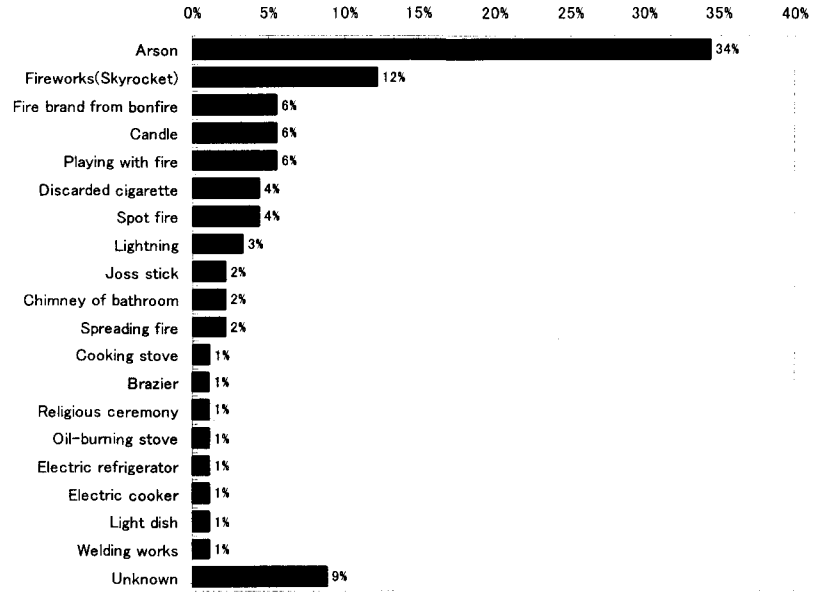


FIGURE 1 Fire Cause in Cultural Property Buildings (total data n=90)

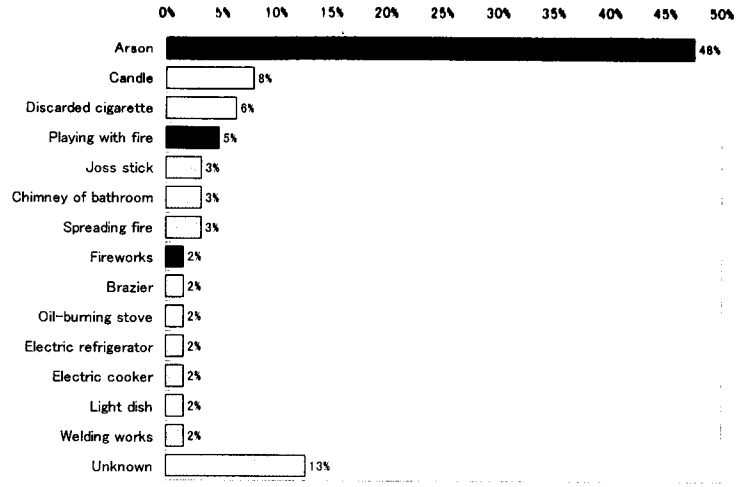
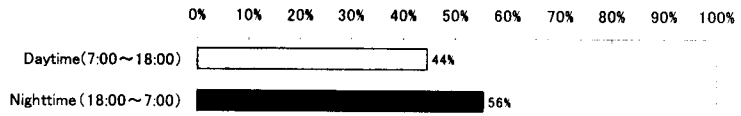
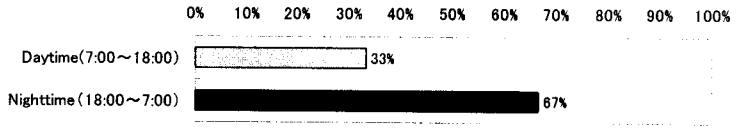


FIGURE 2 Fire Cause
(except where the ignition point is a roof of vegetable materials: n=63)

Figure 3 shows the rates of fire ignition by time of day. The rate of ignition in nighttime for all fires (56%) is a little higher than that the daytime ignition rate (48%). However, for arson, nighttime ignition rate (67%) is twice the daytime ignition rate (33%).



Total Data (n=90)



Fire caused by Arson (n=31)
FIGURE 3 Rates of Daytime and Nighttime Ignition

Figure 4 shows ignition points for all fire cases. Roof, interior and exterior are the main ignition points. For all fires starting in roofs, the roofs are made of vegetable materials. Figure 5 shows arson cases. The percentages of two ignition points, that are interior and exterior, are about the same and both are a higher rate than other ignition points. All arson fires starting under floors were caused by time ignition devices. Figure 6 shows fire ignition points in the interior for all fire cases. There are many unspecified fire ignition points but, as this figure indicates, most were on the floor. Most fires starting on the floor were started by arsonists who scattered gasoline, kerosene and so on and ignited it. The next most common cause was candles used as votive lights falling on the floor.

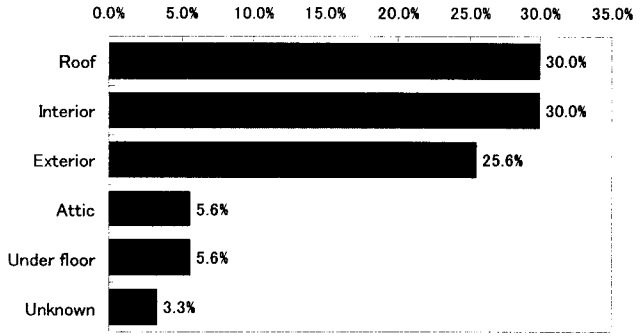


FIGURE 4 Ignition Points for All Fire Cases (n=90)

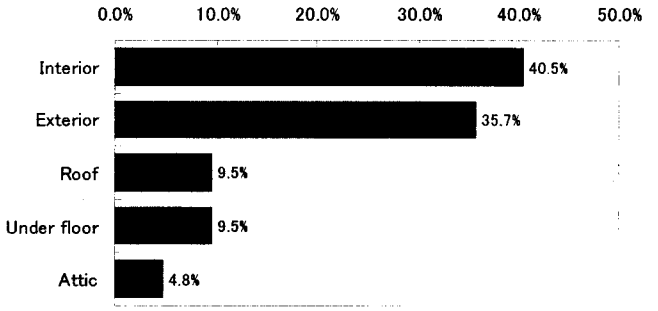


FIGURE 5 Ignition Points for Arson Fires (n=31)

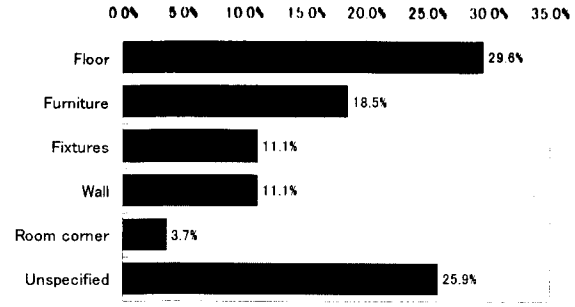


FIGURE 6 Ignition Points in the Interior for All Fire Cases (n=27)

Figure 7 compares shrines and temples concerning whether anybody was in the building that caught fire, and whether anybody was in another buildings on the site when the fire occurred. The rates were high for nobody in the building that caught fire for both shrines and temples. The rate reaches 82.1% of the total cases for shrines. According to reference [1], for all cultural property buildings including buildings other than shrines and temples, the rate for nobody being in the building that caught fire reaches 81.9%. However, the rate for nobody being in a building other than the one that caught fire was 25% for shrines and that for temples was 41.9%. Both rates are low. This means that, in 46.4% of shrines and in 32.3% of temples, nobody was in the building that caught fire, but somebody was on the site when the fire occurred.

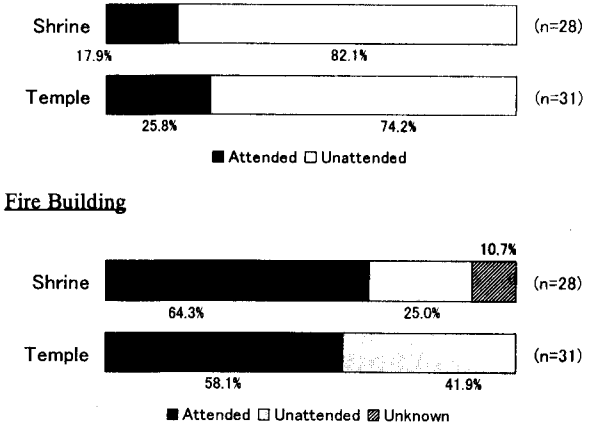


FIGURE 7 Presence of Someone at the Scene

Figure 8 shows the type of building set on fire. The highest rate was for temples (45.2%) and the next highest was for shrines (19.4%). According to 1988 statistics [4], 996 shrines and 964 temples were designated as cultural properties. As these populations are almost the same, it is easy to see that the arson rate for temples is twice as much as that for shrines.

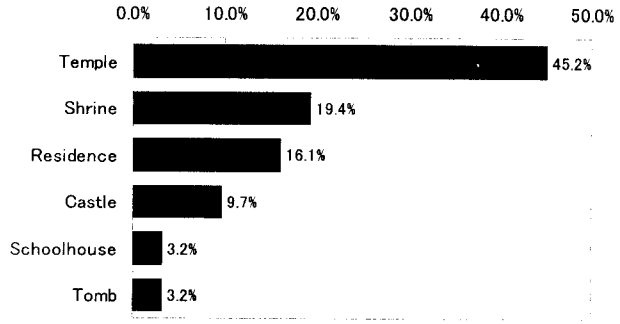


FIGURE 8 Type of Buildings set on Fire (n=31)

FIRE PROTECTION MANAGEMENT OF SHRINES AND TEMPLES

As discussed in the previous section, the most common cause of fire in cultural property buildings is arson. Therefore, it is important to prevent intrusion of outsiders into their precincts when they are closed. Figure 9 compares the percentages of shrines and temples surrounded by a fence or a wall. The rate for temples is 85.7%, but the rate for shrines is only 48.8%. Figure 10 shows the percentages of shrines and temples surrounded with fence and wall whose gates are closed in nighttime. In 78.8% of temples, the gate doors are closed, but the rate for shrines is only 40%. As indicated in Figure 11, the percentage of temples that have a person with a fire protection manager's license is higher than that for shrines'.

Figures 12 and 13 compare the presence of a watch service in shrines and temples. Investigation of fire cases shows a high percentage of cases in which nobody was in the building when the fire occurred. This fact indicates that unattended shrines and temples have a high risk of arson fires. The figures indicate that in 79.2% of temples and in 53.7% of shrines, a voluntary watch service is set for 24 hours. However, even though a watch service was set, a station may be a long way from the burning building. There are few cases in which a watch service is entrusted to a security company for both shrines and temples. To minimize the spread of a fire, it is important to conduct the most thorough fire fighting operations before a municipal fire brigade arrives. Therefore, these institutions should have very effective fire fighting facilities.

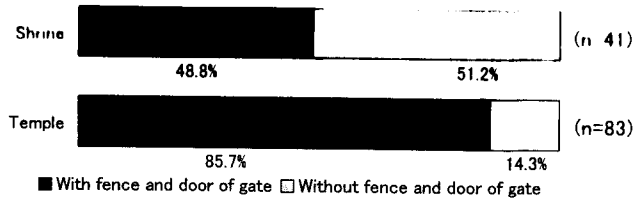


FIGURE 9 Situation of Wall and Doors Setting

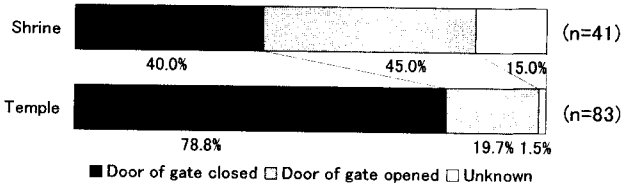


FIGURE 10 Closing Rate of Gate Doors

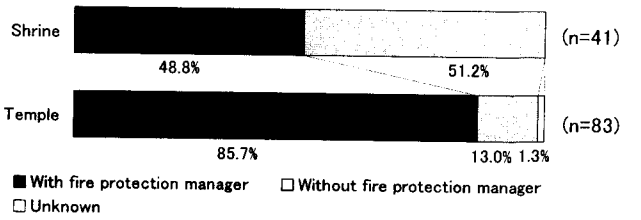


FIGURE 11 Holding Rate of Fire Protection Manager

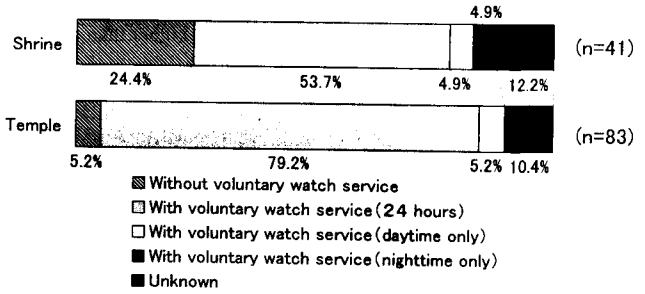


FIGURE 12 Actual Situation of Voluntary Watch Service

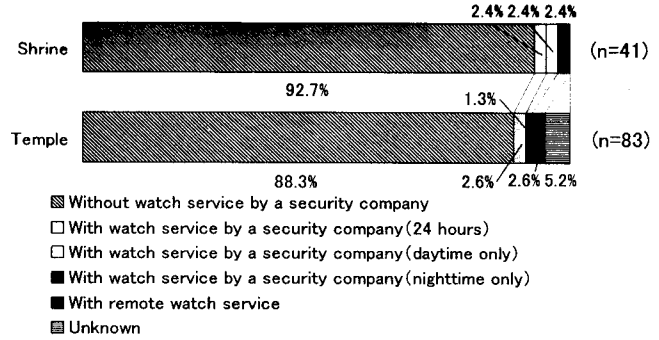


FIGURE 13 Actual Watch Service Rate

Figures 14, 15, 16 and 17 show the percentages of institutions that have an in-house fire brigade, the frequency of fire drills, and the number and age of its members. The percentage of the presence of an in-house fire brigade for temples is higher than that for shrines, but in many temples, the in-house fire brigade has few members. Although fewer shrines have an in-house fire brigade, a higher percentage of those consists of more than 10 people. However, the average age of fire fighters is very high for both shrines and temples. In 15.9% of temples, the average age is over 60. More temples than shrines held fire drills. However, in those shrines that held fire drills, a higher percentage held them more than twice a year.

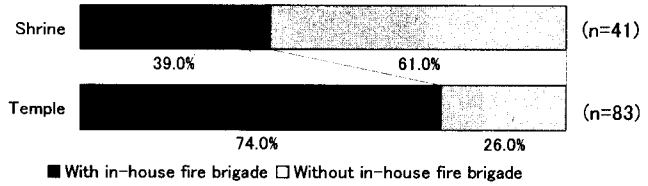


FIGURE 14 In-house Fire Brigade Rate

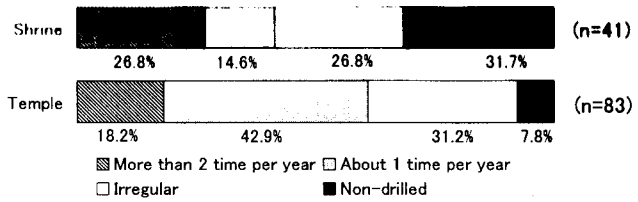


FIGURE 15 Frequency of a Fire Drill

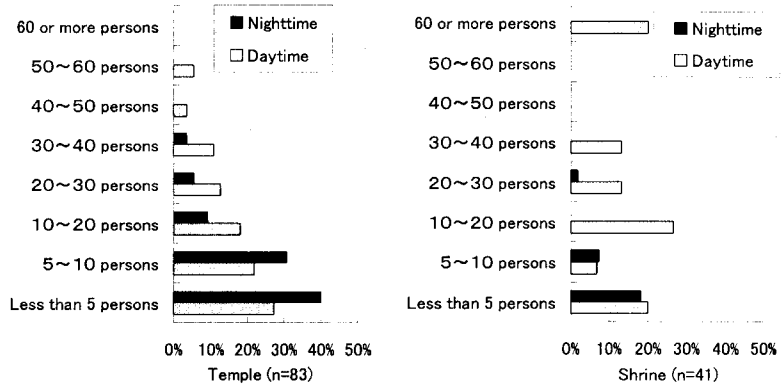


FIGURE 16 Number of In-house Fire Brigade Members

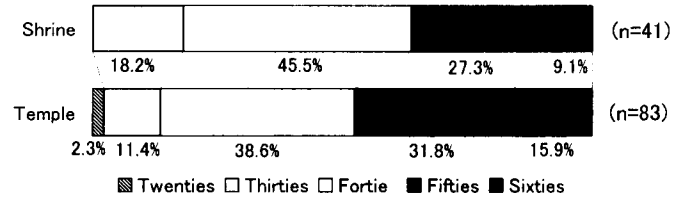


FIGURE 17 Age of In-house Fire Brigade Members

As shown in Figure 18, neighbors' cooperation in case of fire was obtained more often for shrines than for temples. For shrines, there tends to be insufficient fire protection management, as we have seen. However, it is easy to obtain cooperation of volunteer fire departments and neighbors when a fire occurred, because shrines are open to neighboring people.

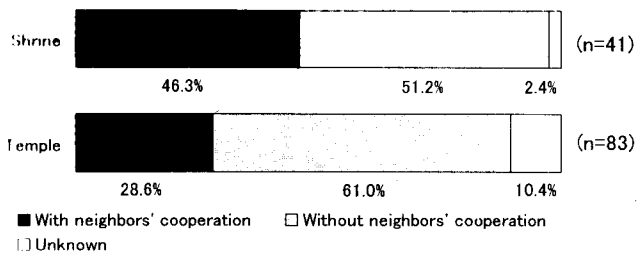


FIGURE 18 Neighbors' Cooperation in Case of Fire

CONCLUSION

This paper has analyzed investigation results of fire cases and actual fire protection management in Japanese cultural property buildings. Two main problems have arisen. The first is that the rate of arson at nighttime is almost half of the total cause of fire, except when the ignition point is in a roof made of vegetable materials. The second problem is that a person was rarely in the building that caught fire. There are two main findings concerning special characteristics of fire protection management. One is that shrines are open to the neighborhood during the daytime and nighttime. Therefore, anybody, including arsonists, can easily enter their precincts. The other is that, more temples, than shrines have a fire protection manager, a watch service and an in-house emergency organization. However, there is a limitation on the quality of fire protection management depending on human beings. For example, many small temples are uninhabited or only an elderly couple live in them. In spite of this, it is clear that the arson rate for temples is twice than that for shrines. The reason for this has not been clarified. There may be other factors affecting the high fire rate, such as ideological issues. To research what traditional wooden buildings in urban area should be in the future, we plan to investigate the building materials and construction methods for shrines and temples in urban areas not designated as cultural properties, as well as material of surrounding buildings.

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Correlation between Physiological Index and Psycological Index during Stressful Fire Drills

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ABSTRACT

The purpose of this study is to obtain a better understanding of human behavior in fire. In this study, we measured the physiological indices (sympathetic nerve, parasympathetic nerve) and the psychological index (questionnaires of feelings factors) during fire drills at the Disaster Prevention-Training Center in Hiroshima, Japan. This training center has a unique stressful training program in which drill participants stay overnight. Devices for measuring physiological index were attached to some participants during fire drills. After the fire drills, we conducted questionnaires of feelings factors value on emergency state. We analyzed physiological indices, psychological indices and correlation between physiological indices and psychological indices. As a result of this study, we understood the following results.

1. High sympathetic nerve value and low parasympathetic nerve value were observed during some trainings in which participants have difficulty to forecast next necessary actions.
2. The correlation coefficients among feelings factors were relatively high.
3. The correlation coefficients among sympathetic nerve values, parasympathetic nerve values and feelings factors values were relatively low. Nevertheless, Maximum of parasympathetic nerve values of ratio for average of 24hours tends to be low in the condition of high feelings factors values.

KEYWORDS: questionnaires of psychology, escape, autonomic nerve, sympathetic nerve, parasympathetic nerve

INTRODUCTION

The characteristics of human behavior in emergencies have been well studied in real fires [1], as well as in experiment. To clarify human behavior in fire, experiments with subjects have been conducted. Horiuchi [2] conducted an experiment in a department store to show that the view of the escape route is a key factor for crowd