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Causes of the Seismic Fires following the Great Hanshin-Awaji Earthquake-Survey

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ABSTRACT

This study will pay particular attention to the causes of the fires that occurred simultaneously and in large numbers following the earthquake. In order that such a massive disaster never repeats itself, we must accurately determine what events took place during this earthquake and what measures were taken. The seven cities targeted for in Hyogo Prefecture and the seismic fires considered here are those that started over the three days immediately following the earthquake between January 17, 18 and 19. Interview surveys with residents in areas that were judged to be the source of fires, concerned whether the fires actually occurred, determining the spots of fire outbreaks, and studying the causes of the fires, the spreading of fires, and fire-fighting activities. . The number of seismic fires that started immediately after the earthquake up to January 19 totaled 181 in surveyed cities, then 96 were single fires and 85 were spread fires. Out of the 84 fires whose causes could be conjectured, a total of 56 cases (66.7%) were related to electricity and gas; the major characteristic of the Great Hanshin-Awaji Earthquake. In the North Ridge Earthquake of 1994, it is also conjectured that many fires were caused by a similar phenomenon.

1. Introduction

On January 17, 1995 at 5:46 a.m., the Hanshin area was hit by a violent earthquake, measuring 7 on the Japanese seismic scale. The epicenter was under the northern part of Awaji Island. The earthquake registered 7.2 on the Richter scale and the shallow depth of the epicenter was only about 20 km; unusual for earthquakes. Having occurred immediately beneath large cities such as Kobe, the temblor produced enormous damage. The life-support services of electricity, water, and gas were cut and transportation networks of roads and railways were paralyzed. Amidst these circumstances, fires broke out simultaneously and in large numbers, sending up raging flames in numerous places across town and spewing up black columns of smoke. Indeed even several minutes after the earthquake 60 fires broke out simultaneously in Kobe city area, but only eighty pomper teams with 292 firemen, who belong to Kobe city Fire Department, could arrest the spread of fires just after the earthquake. This event happened before the lessons from the North Ridge Earthquake that occurred in the United States in 1994 could be fully digested. The Great Hanshin-Awaji Earthquake again clearly brought to fore the characteristics and problems of seismic fires.

2. Method of Study

2.1. Scope of investigation

The seven cities targeted for survey were Kobe, Amagasaki, Nishinomiya, Ashiya, Takarazuka, Itami and Kawanishi in Hyogo Prefecture. The seismic fires considered here are those that started over the three days immediately following the earthquake on January 17.

2.2. Method of interview survey

Using the fire list of the fire departments of the above seven cities of between January 17, 18 and 19, interview surveys with residents in areas that were judged to be the source of fires, concerned whether the fires actually occurred, determining the spots of fire outbreaks, and studying the causes of the fires, the spreading of fires, and fire-fighting activities.

2.3. Compilation of fire list

In areas where many fires started at the same time, the work of sorting through the lists of all reported fires is in itself a large task. Therefore, surveys were undertaken as lists became available.

2.3.1. With regard to the cities of Kobe and Nishinomiya, the fire report lists were obtained from the municipal fire departments and interviews on residents were duly conducted. Later, supplementation and correction of exact location of fire outbreaks were conducted, based on the new report lists obtained afterwards from the municipal fire authorities and from the research findings from fire sites as issued by the Ministry of Construction's Building Research Institute.

2.3.2. With regard to the cities of Amagasaki and Ashiya, the fire survey findings gathered by the cities' fire departments were obtained, and based on these findings, the number of fires were determined and interviews with residents were held.

2.3.3. With regard to the cities of Itami, Takarazuka and Kawanishi, the causes of fires were determined based on the investigation results of the fire departments. Interviews with residents were not conducted.

3. General Facts about the Fires

3.1. Number of fires

The number of fires that started immediately after the earthquake up to January 19 totaled 181 in the seven cities surveyed. Table 1 gives a breakdown according to the size of fires. Ninty-six were single fires (fire was limited to one building, or in the case of an apartment block, even if the fire spread from one apartment to another, the fire was contained within the same block) and 85 were fires where flames spread to affect more than one building.

3.1.1. Regarding the size of the fires that spread, small-scale fires (less than 1,000 m^2 of fire spread) numbered 34, medium-scale fires (1,000 m^2 or more but under 3,300 m^2) numbered 24, and large-scale fires (3,300 m^2 or more) numbered 27. Fires of 33,000 m^2 or more

numbered 10.

Note 1) The figures for the amount of areas burnt by fire were taken from data given by the Ministry of Construction, Building Research Institute. In general, areas burnt in fires are determined according to the area of the building , but here, the land area was used for its measure.

Note 2) Because there are cases when more than one exact location of fire breaks combined to form a large-scale fire, the number of large-scale fires became 22.

Fig. 1 examines the relation between the number of fires starting and the time elapsed after the earthquake. Out of the 181 incidents of fire, 91 (50.3%) started within one hour of the earthquake. There were 137 fires (75.7%) that started within 6 hours, and 157 (86.7%) within 24 hours. After 24 hours, 23 fires (12.7%) broke out. Thus, the striking feature of this earthquake is that many fires started long after the earthquake's occurrence.

Table 1 Number of fires according to the size

	single bldg.	small-scale	medium-scale	large-scale	Total
Kobe city	44	23	21	17	115
Higashinada-ku	9	3	5	3	20
Nada-ku	5	6	4	3	18
Chuo-ku	16	3	3	0	22
Hyogo-ku	1	5	4	4	14
Nagata-ku	3	2	3	14	22
Suma-ku	3	4	2	3	12
Tarumi-ku	5	0	0	0	5
Kita-ku	1	0	0	0	1
Nishi-ku	1	0	0	0	1
Amagasaki city	5	0	2	0	7
Nishinomiya city	23	7	1	0	31
Ashiya city	11	3	0	0	14
Takarazuka city	3	1	0	0	4
Itami city	7	0	0	0	7
Kawanishi city	3	0	0	0	3
Total	96	34	24	27	181

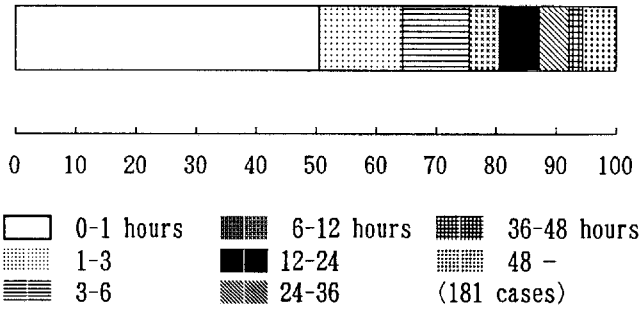

Fig 1 When fires occured after the Earthquake?

3.2. Incidence of fire

Table 2 gives the incidence of fire broken down by cities and wards (the number of fires starting per 10,000 households). Taking areas in the seven cities surveyed as a whole, the rate was 1.68; however, in the Chuo and Nagata wards of Kobe City, and in Ashiya City, the incidence was high at over 4.00.

Table 3 gives the incidence of fires in major earthquakes of the past. The only earthquake that had previously registered 7 on the Japanese scale was the Fukui Earthquake of 1948. The incidence of fire in Fukui City at that time was as high as 15.5. Comparing this with the Great Hanshin-Awaji Earthquake, the incidence is far lower than that of the Fukui

Table 2 Incidence of fire broken down by cities and wards

	N of fires	N of family	Incidence of fire
Kobe city	115	530063	2.17
Higashinada-ku	20	72625	2.75
Nada-ku	18	53530	3.36
Chuo-ku	22	50146	4.39
Hyogo-ku	14	51726	2.71
Nagata-ku	22	52308	4.21
Suma-ku	12	61664	1.95
Tarumi-ku	5	80664	0.62
Kita-ku	1	46267	0.22
Nishi-ku	1	61133	0.16
Ashiya city	14	32186	4.35
Nishinomiya city	31	156671	1.98
Itami city	7	62556	1.12
Kawanishi city	3	43906	0.68
Amagasaki city	7	183842	0.38
Takatazuka city	4	67357	0.59
Total	181	1076581	1.68

Table 3 Incidence of fires in major earthquakes of the past in Japan

Name of Earthquake in the past	Kanto EQ.	Fukui EQ.	Niigata EQ.	Tokachi-oki EQ.	Miyagi-oki EQ.
year	1923	1948	1964	1968	1978
date	Sep.1	Jun.28	Jun.16	May.16	Jun.12
season	summer	summer	summer	spring	summer
time	noon 11:58	evening 16:13	afternoon 13:01	morning 9:49	evening 17:14
Japanese seismic scale	6	7	5	5	5
Incidence of fire per 10,000 family	2.02	15.5	1.26	1.78	0.373
Incidence of civil fire-fighting	41.4%	0.0%	44.4%	57.1%	50.0%

Note 1) The fire incidence of the Great Kanto Earthquake (1923) and the Fukui Earthquake (1948) is given per 10,000 houses.

Table 4 Causes of fire which could be conjectured

time elasped after EQ	hrs 0-1	1-6	6-12	12-24	24-48	48-	Total
leak of gas + catching fire	4	3	1	1	1	0	10
other reasons with gas appliance (appliance for boiling water etc.)	4	1	0	0	0	0	5
leak of gas + electrical leak	4	4	0	1	0	0	9
electrical leak · short	4	3	0	0	1	2	10
other kind of electric appliance (electrical stove etc.)	2	5	0	3	0	2	12
other reasons with gas appliance A kind of electric	2	5	0	1	2	0	10
kind of kerosene stove	7	0	1	1	0	0	9
others	12	1	1	2	1	2	19
T o t a l	39	22	3	9	5	6	84

Table 5 Causes of fire in past major earthquakes in Japan

Causes of fires	Kanto EQ. (1923)	Fukui EQ. (1948)	Niigata EQ. (1964)	Tokachi-oki EQ. (1968)	Miyagi-oki EQ. (1978)
medicine (or gunpowder)	47	11	3	4	7
gas	15	—	—	—	2
portable cooking stove	181	10	1	—	—
by charcoal fire, brazie kitchen, cookroom	43	17	—	—	—
kerosene cooking stove	3	—	—	6	—
kerosene stove	0	—	—	13	—
others (electric leak, candle, chacoal fire)	38	5	5	19	6
unknown	18	—	3	3	—
a leap of the flames	68	—	—	—	—
Total	413 (345)	48	12	45	15

Note) The numbers of fires given for the Great Kanto Earthquake (1923) are those that occurred in the then Tokyo and Kanagawa Prefectures.

The numbers of fires given for the Miyagi Offshore Earthquake (1978) are those that occurred in Miyagi Prefecture./E

by kerosene stoves.

After this, the anti-seismic extinguishing device for kerosene stoves became mandatory. Nonetheless, in the Great Hanshin-Awaji Earthquake, 9 fires (10.7%) broke out because of kerosene stoves.

5. Causes of Fire Analyzed by Time

5.1. Causes of fire starting within one hour of the earthquake

5.1.1. The number of fires that started due to electrical reasons was 8 in the first hour. This is probably because electricity supply was cut off after the earthquake but returned immediately because of the automatic power restoration system.

5.1.2. Of all the 15 fires directly caused by gas, 8 occurred immediately after the earthquake. This is thought to be because the computerized shut-off devices which are supposed to cut the gas supply did not operate effectively and as a result, gas filled the damaged buildings or rubble, and was ignited.

5.1.3. Out of the 9 fires caused by kerosene stoves, 7 started immediately after the earthquake. These are believed to have started because the anti-seismic devices of kerosene stoves did not work effectively due to the sudden shock of the earthquake or because old types or broken stoves were being used.

5.1.4. Other causes of fire starting immediately after the earthquake include: automobile (4 cases), candle (1), charcoal (%%rentan%%) (1), cigarette (1), chemicals (3), and propane gas (2), making a total of 12 fires. Fires caused by naked flames created by the burning of charcoal, etc. decreased dramatically in comparison with past earthquakes.

5.2. Causes of fires starting more than one hour after the earthquake

5.2.1. Twenty four out of the 32 fires due to electrical causes started between one hour and 3 days after the earthquake. More fires broke out during this time sequence than immediately after the earthquake. The reason for this is thought to be caused by the power restoration system after the electricity was initially cut. It is conjectured that fires started because power supply was resumed, without due consideration given to the state of damage of the buildings in the area or the state of the electrical facilities and equipment remaining the buildings.

5.2.2. Seven out of the 15 fires caused by gas started more than one hour after the earthquake. The reason for this is thought to be the delay in the emergency shut-off of supply. In the interviews, eye-witnesses accounts state that gas flames rose up for several hours after the earthquake.

5.2.3. Other causes of fire include: kerosene stove (2), candle (2), and portable cooking stove *(shichirin)* (1), making for a total of 5 fires. These are thought to be accidental fires because fire was used to obtain heat and light, in conditions where there was no gas, water, or electricity, by people who were not staying in emergency shelters.

Besides these, other cases of fire broke out as time passed following the earthquake, including cases of rescue workers using oxyacetylene equipment causing 2 fires, as well as 2 cases of arson.

6. Summary

The research on the recent Great Hanshin-Awaji Earthquake was conducted through interviews with residents for the purpose of determining the numbers of fires and causes of fires. However, in many places such as Nagata ward, where the fire was of a massive scale, it was difficult to find people who were actually present at the time the fire started, making it difficult to specify the cause of fire. Work will be continued on determining the causes of these fires.

The facts to be noted are that the fires occurred in many places at once, that there was difficulty in water availability because of burst water mains, that there were delays in fire-fighting equipment arriving at the site because of traffic chaos, and that there was difficulty in systematic organization because of the confusion in communication networks. Owing to these and other factors, if fires break out at the same time and at many different locations, it becomes impossible for public fire-fighting forces to respond to the situation.

In the case of scale 7 earthquakes, the firefighters have an inordinately difficult situation to contend with. The lesson for the future is that we must plan countermeasures in a step-by-step manner, as in preventing fires from occurring, in preventing fires from spreading, and in protecting the lives of residents. What is most important among these is to establish measures for preventing fires from breaking out in the first place. To prevent fires, we must scientifically reveal every single one of the causes of such fires and find the means to overcome them.

In addition, we need to reexamine the method for the restoration of electricity and the system for the cutting off of the gas supply.

7. Acknowledgement

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