

## FIRES FOLLOWING THE GREAT HANSHIN EARTHQUAKE IN KOBE

### INTRODUCTION

At 5:46 a.m., on January 17, 1995, an earthquake, which epicenter was only 14 km under the ground and the hypocentral region was just beneath Kobe city, registered 7.2 on the Richter scale. As Kobe city is Japan's sixth largest city with a population of 1.4 million, the damage caused by this massive earthquake was the worst in postwar Japan. The Great Hanshin Earthquake destroyed more than 200,000 buildings killing more than 5,500 people, and injuring and burying over 40,000 others. More than 200 fires broke out after the earthquake and burnt down more than 7,000 houses or areas of over 65 hectares killing more than 350 people who had been buried under the damaged structures.

### LARGE NUMBER OF SIMULTANEOUS IGNITIONS

During the first 3 days following the earthquake, more than 200 fires occurred in Hyogo and Osaka prefectures <sup>1)</sup>. Of those, 138 fires took place in Kobe city <sup>2)</sup>. Table 1 lists number of post-earthquake fires by date in 7 cities where the damages of structures were very severe. In 13 minutes after the earthquake, 60 fires broke out in Kobe city. Figure 1 shows 150 fire sites where the investigations by Building Research Institute were conducted.

**Table 1. Number of Post-earthquake Fires by Date in Kobe, Ashiya, Nishinomiya Takarazuka, Itami, Kawanishi and Amagasaki in Hyogo Prefecture.** <sup>2), 3)</sup>

Name of Ward and City	Jan. 17 -6:00	Jan. 17 -7:00	Jan. 17 -8:00	Jan. 17 -9:00	Jan. 17 -24:00	Jan. 17 Total	Jan. 18 Total	Jan. 19 Total	Total
Nishi	1	0	0	0	0	1	0	0	1
Tarumi	0	0	0	0	6	6	0	0	6
Suma	4	4	0	4	1	13	2	1	16
Nagata	13	1	0	0	3	17	1	4	22
Hyogo	11	0	2	1	3	17	4	3	24
Kita	0	0	0	0	1	1	0	0	1
Chuo	8	4	2	1	5	20	3	3	26
Nada	13	0	1	1	2	17	2	0	19
Higashi-Nada	10	1	2	1	3	17	2	4	23
<b>Kobe</b>	<b>60</b>	<b>10</b>	<b>7</b>	<b>8</b>	<b>24</b>	<b>109</b>	<b>14</b>	<b>15</b>	<b>138</b>
Ashiya	6	3			2	11	1	2	14
Nishinomiya	7	11	4	1	3	26	2	3	31
Takarazuka	2				2	4			4
Itami	2	2	2	1		7			7
Kawanishi	1	2				3			3
Amagasaki	3	2			2	7			7
<b>Total</b>	<b>81</b>	<b>30</b>	<b>13</b>	<b>10</b>	<b>33</b>	<b>167</b>	<b>17</b>	<b>20</b>	<b>214</b>

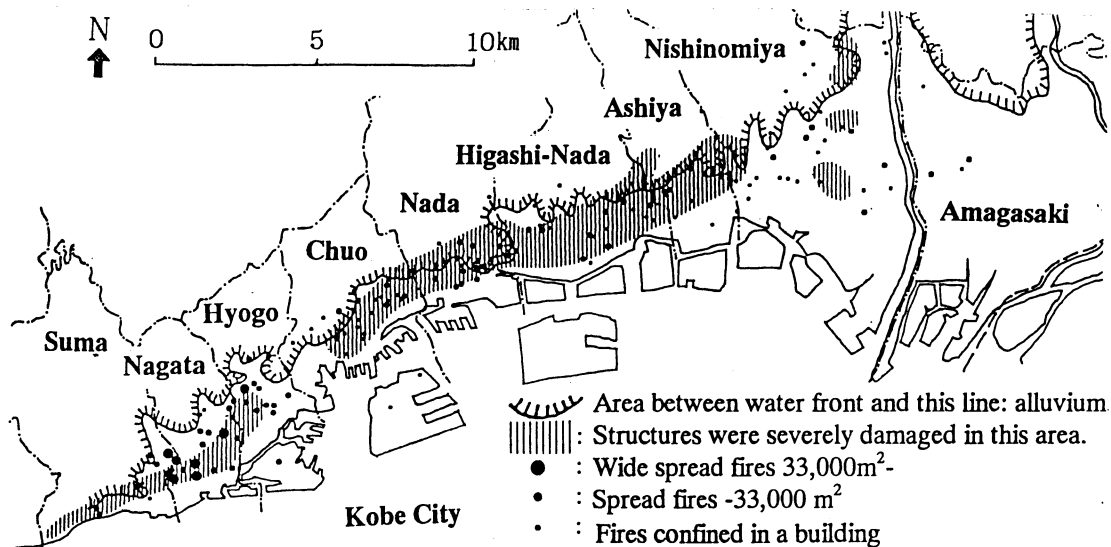


Figure 1. 150 Investigated Fire Sites ( Major Fires are included )

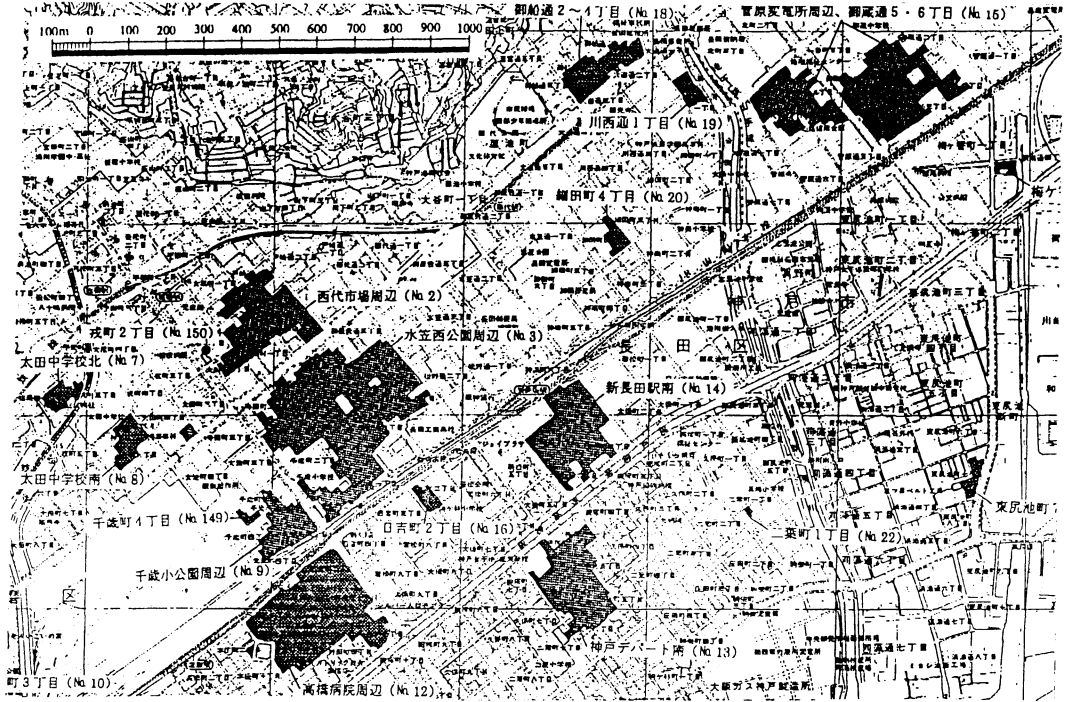
### LARGE CONFLAGRATIONS

Table 2 lists Number of large fires ( burned area,  $3,300\text{m}^2$  ), middle fires (  $1,000\text{-}3,300\text{m}^2$  ), small fires (  $\text{-}1,000\text{m}^2$  ), confined fires and fire loss. 7 fires spread over  $33,000\text{m}^2$ .

Table 2. Number of Post-earthquake Fires by Area and Fire Loss <sup>1), 2), 4)</sup>

Name of Ward and City	No. of Large Fires	No. of Middle Fires	No. of Small Fires	No. of Confined Fires	Total No. of Fires	Total Number of burned Buildings	Total area of fire sites: $\text{m}^2$
Nishi	0	0	0	1	1	1	77
Tarumi	0	0	0	5	5	5	173
Suma	3	2	4	3	12	351	98,552
Nagata-Suma	-	-	-	-	-	1583	-
Nagata	14	3	2	3	22	2926	303,558
Hyogo	4	4	5	1	14	972	127,055
Kita	0	0	0	1	1	1	54
Chuo	0	3	3	16	22	88	14,542
Nada	3	4	6	5	18	561	65,318
Higashi-Nada	3	5	3	9	20	333	32,886
Kobe	27	21	23	44	115	6814	642,215
Ashiya	0	0	3	11	14	22	2,925
Nishinomiya	0	1	7	22	30	66	8,259
Takarazuka	0	0	3	11	14	-	-
Itami	0	0	0	7	7	7	-
Kawanishi	0	0	0	3	3	3	-
Amagasaki	0	2	0	5	7	10	2,090
<b>Total</b>	<b>27</b>	<b>24</b>	<b>34</b>	<b>95</b>	<b>180</b>	<b>6922</b>	<b>655,489</b>

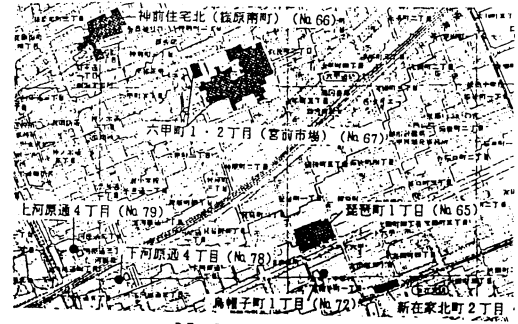
Figure 2 shows large conflagrations which area is over 3,300 m<sup>2</sup> in Nagata, Suma, Hyogo, Nada and Higashi-Nada Ward.



Nagata and Suma Ward



Hyogo Ward



Nada Ward



Higashi-Nada Ward

Figure 2. Large Conflagrations in Kobe City<sup>4)</sup>

## HINDRANCE TO FIREFIGHTING

Public firefighting capabilities were severely strained after the earthquake. Fire departments were inundated with numerous demands involving, not only fire, but structural damage, search and rescue, gas leaks, and medical aid. There were more than 10,000 people who were buried under the rubble and some dispatched firefighters were forced to rescue buried people instead of putting out the fires. 80 fire brigades of 292 firefighters at 11 fire stations in Kobe city responded these demands at first hand. In 5 hours, 90 percentage of 1,094 fire fighters came to their fire stations<sup>5)</sup>. Table 3 shows the number of fires in 13 minutes after the earthquake and the number of fire brigades which were on duty at 6:00 a.m., on January 17, 1995. The firefighting forces were overwhelmed by large number of simultaneous ignitions. In the wards where the number of fires at 6:00 a.m. is greater than the number of fire brigades on duty at that time, fires spread very widely.

**Table 3. Number of fires in 13 minutes after the earthquake and the number of fire brigades which were on duty at 6:00 a.m., on January 17, 1995 in Kobe<sup>2),5)</sup>.**

Name of Ward	No. of fires at 6:00 a.m.	No. of Large Fires (3,300 m <sup>2</sup> - )	No. of Fire Brigades on Duty at 6:00 a.m.	No. of Fire Fighters on Duty at 6:00 a.m.
Nishi	1	0	8	29
Tarumi	0	0	8	29
Suma	4	3	9	33
<i>Nagata</i>	<i>13</i>	<i>14</i>	7	24
<i>Hyogo</i>	<i>11</i>	4	6	22
Kita	0	0	11	37
Chuo	8	0	16	63
<i>Nada</i>	<i>13</i>	3	7	26
<i>Higashi-Nada</i>	<i>10</i>	3	8	29
Total	60	27	80	282

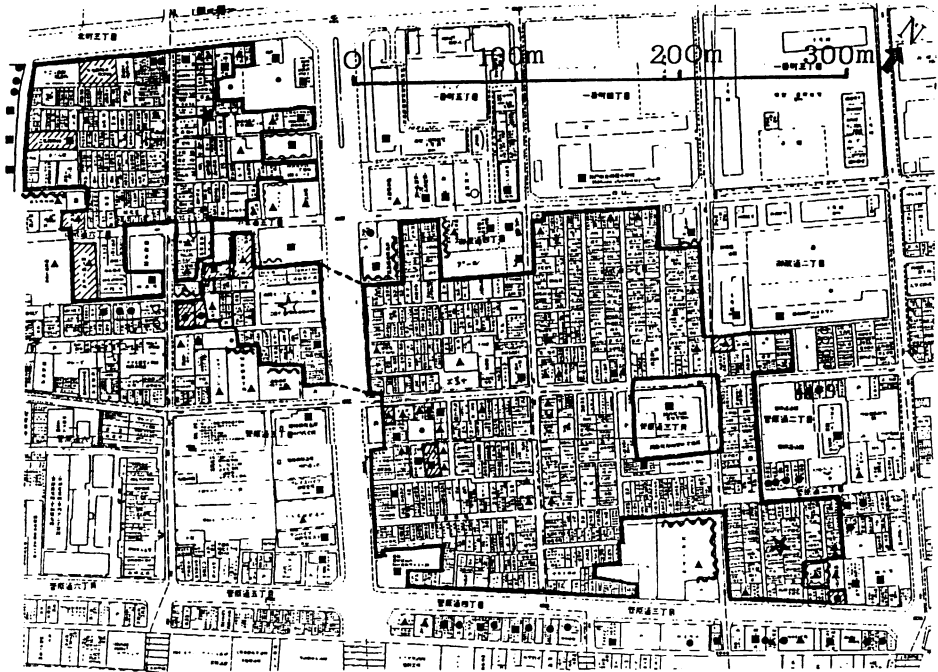
The wards indicated with italic fonts had greater number of fires than fire brigades.

There were traffic congestion with private cars on the main streets where the traffic lights were not working because of the power failure. This traffic jam and the collapsed buildings on the narrow streets caused delay of fire brigades arrival within the city and from other cities as mutual aid. The shortage of water was the primary factor in conflagration. Fire hydrants and in Kobe city were damaged by the tremble and small underground fire tanks had limited quantity of water. Inoperable fire hydrants forced firefighters to draw water from school swimming pools, the Shin-Minato River and finally from the port. Fire hoses were extended more than 1 km from the port and were often broken on the main streets by trespassing vehicles. Fire officials requested that the Water Works Department provide the water held in the reservoirs to fight blazes, but they declined to give a quick reply, saying they wanted to ensure that supplies of drinking water were continued. Nearly 12 hours after the quake, the reservoir water was released to fight the fires<sup>6)</sup>.

## FIRE SPREAD MECHANISMS

In addition to hindrance to firefighting, the fire spread widely because the buildings were so close together especially in Nagata and Hyogo ward. In those fire sites in Nagata and Hyogo ward,





Index for building structure

- : Fire resistive building
- ▲ : Semi-fire resistance building
- : Wooden building with non-combustible materials on the exterior wall
- : Wooden building without non-combustible materials on the exterior wall

Index for Ignition

- ☆ : Fire origin ( Estimated by the evidence of sight )

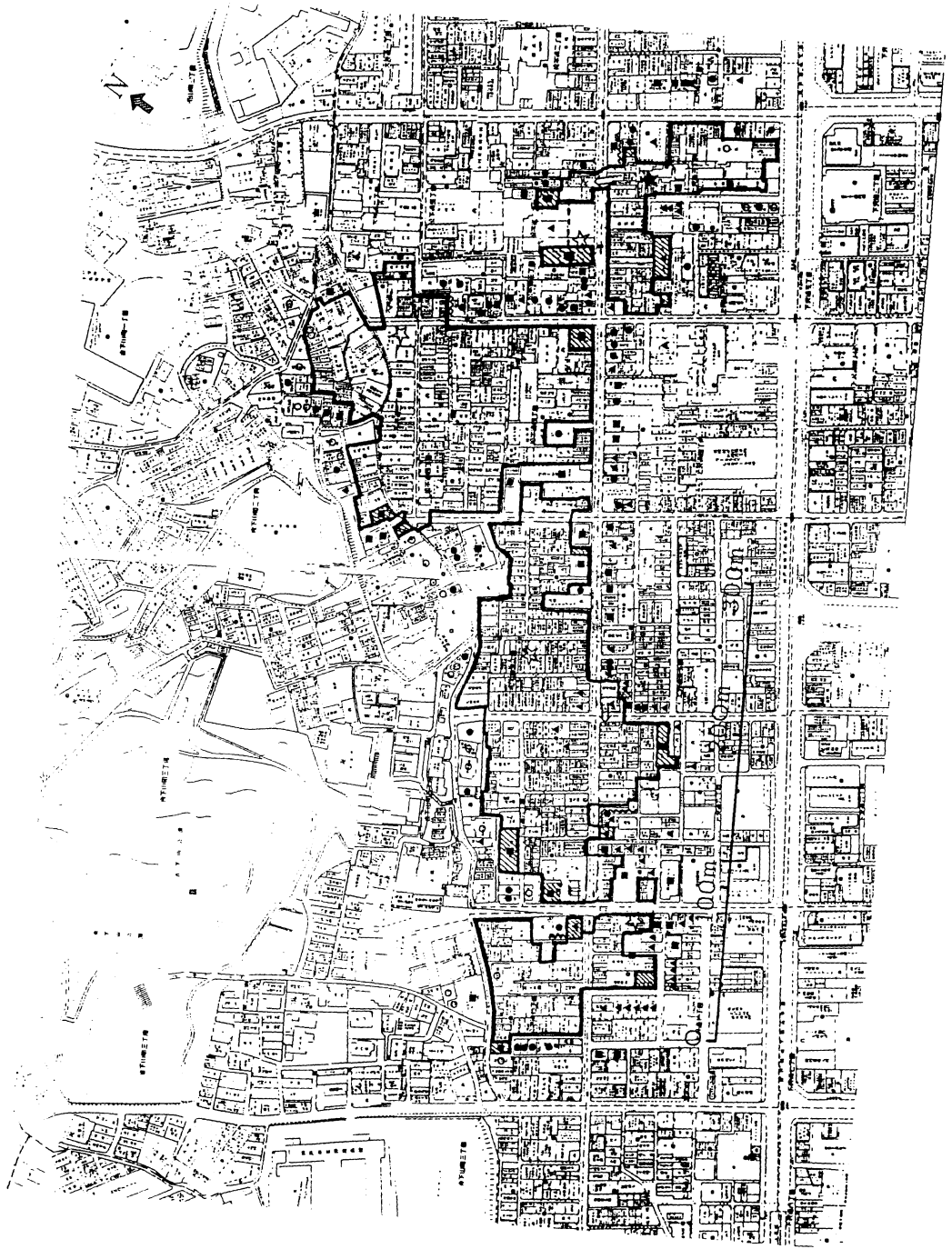
Index for Fire Spread

- ☆ : Ignition by burning wood and embers flying through the air  
( Estimated by the evidence of sight )
- ⇐ : Fire Spread through the collapsed building on the street by fire

Index for Fire-Arresting Line

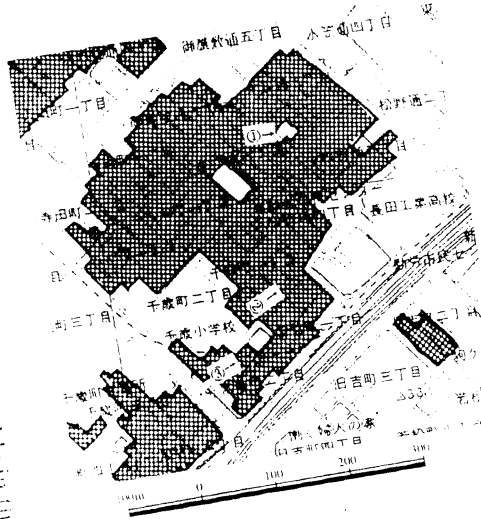
- : Fire spread boundaries
- ▨ : Partially burned building
- ~ : Fire damage only on the exterior wall

Figure 4. Fire Site around the Sugawara Market



**Figure 5. Fire Site of Eigeyama South**

Figure 6. Buildings and rubble in the fire site around the Mizukasa Nishi Park



① Survived buildings midst of the fire site.



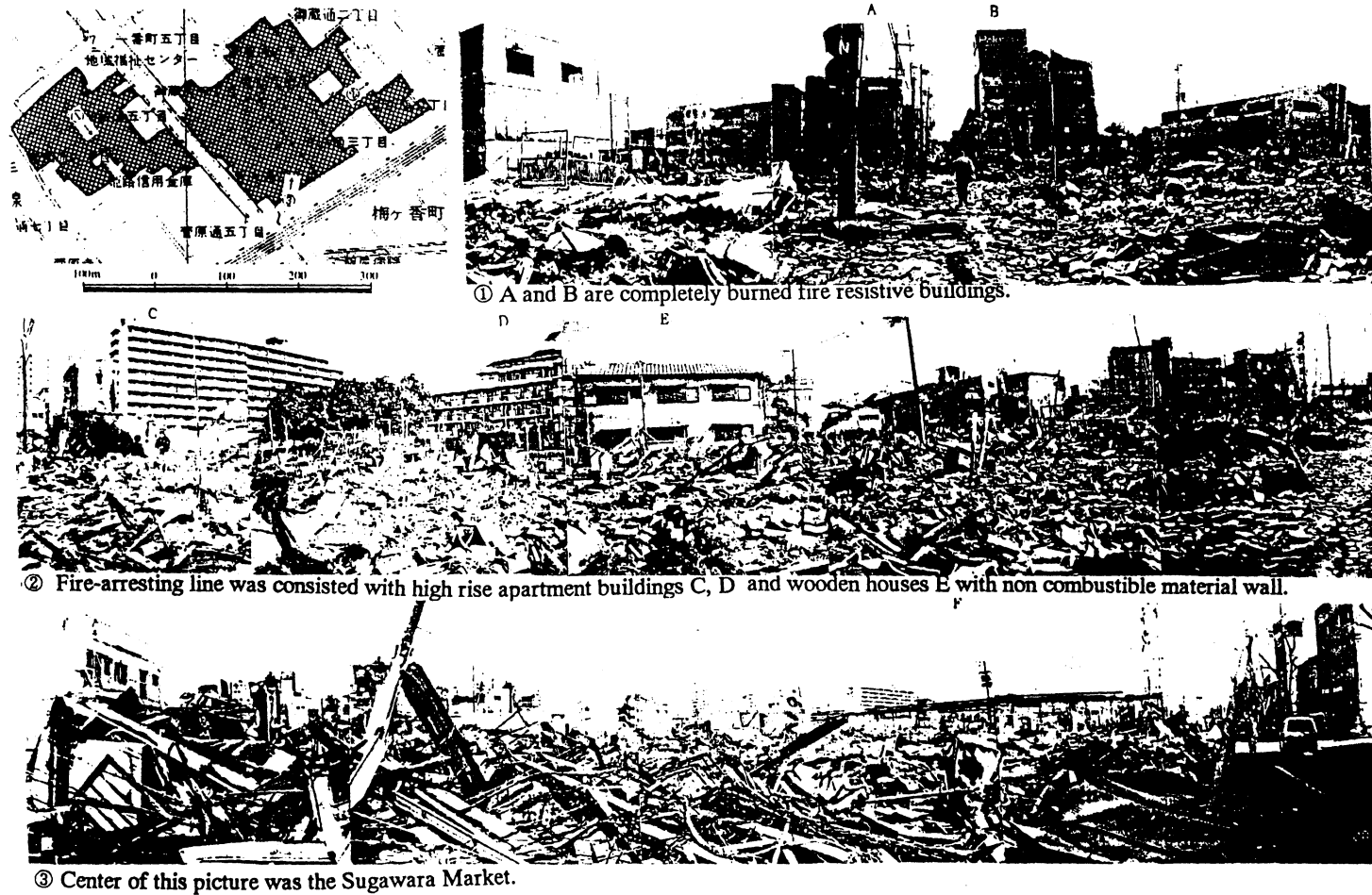
② Burned fire resistive buildings at the center were factories.

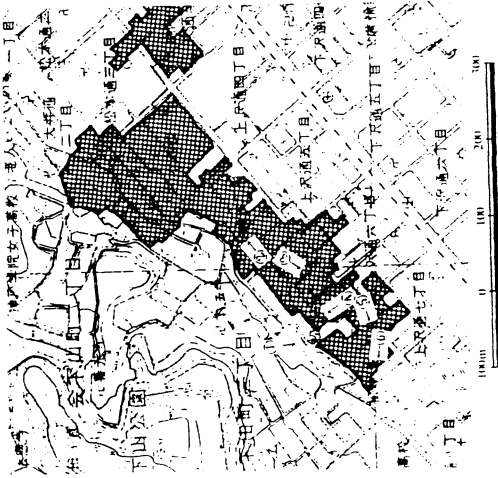


③ Fire spread between building A and B.



Figure 7. Buildings and rubble in the Fire Site around the Sugawara Market



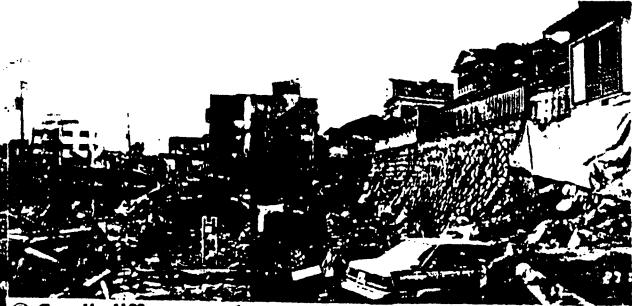


① Houses collapsed on the narrow street.

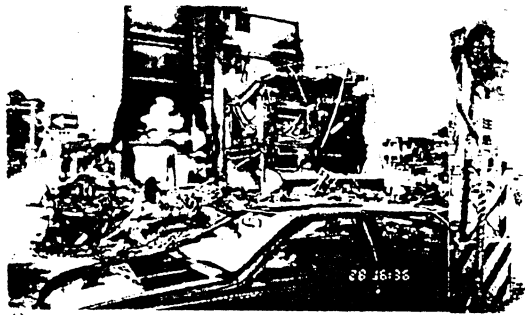


② All building in this fire site were dwellings.

Figure 8. Buildings and rubble in the Fire Site of Eigeyama South



③ Small cliff was an element of fire-arresting line.



④⑤ Fire spread between fire resistive buildings.



⑥ Change of wind direction contributed to make the fire-arresting line.

## FIRE-ARRESTING LINE

Figure 3, 4, 5, 6, 7 and 8 show the buildings which were not burned or partially burned at fire-arresting lines of larger fire sites<sup>4)</sup>. Table 4 indicate the fire stop factors at the fire-arresting lines around the major large fire sites which area exceeds 33,000 square meters<sup>7), 8)</sup>.

**Table 4. Fire Stop Factors at the Fire-Arresting Lines<sup>7), 8)</sup>**

Major Fire sites	Main Street, Railroad	Open Space	Fire Resistive building	Suppression	Total m	Area <sup>4)</sup> m <sup>2</sup>	Ignition Time <sup>3)</sup>
Mizukasa Nishi Park	42%	23%	27%	8%	2,345	121,783	7-9 a.m.
Sugawara Market	40	33	27	0	1,320	77,297	instant
Takahashi Hospital	65	24	10	2	1,258	68,850	instant
Eigeyama South	23	34	25	17	2,745	61,337	instant
Shin-Nagata Sta. S.	59	11	25	5	1,058	39,570	instant
Kobe Department S.	24	16	34	26	1,080	35,100	7 a.m.
Nishidai Market	23	25	28	24	1,195	34,407	instant
Total	38	25	25	12	11,001	438,344	-

Ignition time is of 17 January 1995.

## CONCLUSION

Fortunately the wind was weak during the first hours after the earthquake, catastrophic fires such as the 1923 Great Kanto Earthquake Fire were avoided. Further studies including detailed analysis of fire spread mechanisms and experimental study for the condition with strong winds are necessary for the disaster prevention planning.

## REFERENCES

- 1) Murosaki, Y.; Problems around the fires following the 1995 Southern Hyogo Prefecture Earthquake, Proceedings of the Symposium on Earthquake and Fires, Japan Association for Fire Science and Engineering, 26 May 1995.
- 2) Fire Department of Kobe City; Fires following the 1995 Southern Hyogo Prefecture Earthquake, 14 April 1995.
- 3) Murosaki, Y. et al at Kobe Univ. and Institute of Environment & Safety Planning; Fire Spread in the 1995 Great Hanshin and Awaji Earthquake, 28 March 1995.
- 4) Building Research Institute; The Investigation Report on the 1995 Southern Hyogo Prefecture Earthquake, February 1995.
- 5) Fire Department of Kobe City; The Report on the fire fighting in Kobe city for the fires following the 1995 Great Hanshin Awaji Earthquake, March 1995.
- 6) The Japan Times; Kobe reservoir wasn't used, 9 March 1995.
- 7) Fire Research Institute; The Investigation Report on the Fires and Fire Stop Factors in Kobe City in the 1995 Southern Hyogo Prefecture Earthquake, March 1995.
- 8) Sekizawa, A.; The data and Information on the Fires in the 1995 Southern Hyogo Prefecture Earthquake, for the 1995 FORUM Meeting in Tsukuba, Japan, 13 June 1995.