8. Damage of Buildings, etc. due to Fire

8.1 Objective of Survey

Large number of fires occurred in wide area due to the earthquake and tsunami brought severe damage to buildings. The entire image of the fires is analyzed in this chapter. Investigation has been conducted in order to grasp the circumstances of the fire spreading and fire stopping in large city fires and the damage of building fires.

8.1.1 Number of Fire Occurrence

In this earthquake disaster, enormous tsunami damage occurred, but large number of fires were also identified in the areas damaged by tsunami. This is a major feature of fire damage in this earthquake disaster.

The total 345 fires including non-building fires reported (as of April 20, 2011) by Fire and Disaster Management Agency (FDMA) of Ministry of Internal Affairs and Communications (MIC)[8.1-1]. Table 8.1-1 shows the number of fires in each prefecture. In Miyagi, more than half of the total number of fires was occurred. These 345 fires include not only fires occurred in the mainshock at 14:46 on March 11, but also ones in aftershocks.

Table 8.1-1 Number of Fires by prefectures

Prefecture	Number of Fires
Aomori	5
Iwate	26
Miyagi	194
Akita	1
Fukushima	11
Ibaraki	37
Gunma	2
Saitama	13
Chiba	14
Tokyo	35
Kanagawa	6
Shizuoka	1
Total	345

(FDMA, as of April 20)

8.1.2 Seismic Intensity and Fire Occurrence

In Japan, the relation between fire break-out ratio and seismic intensity has been often discussed in order to identify the feature of earthquake fire[8.1-2].

The relation between seismic intensity and fire break-out ratio in this earthquake is shown in Fig. 8.1-1 and Table 8.1-2. The numbers of fires in some municipalities without seismic intensity data are omitted.

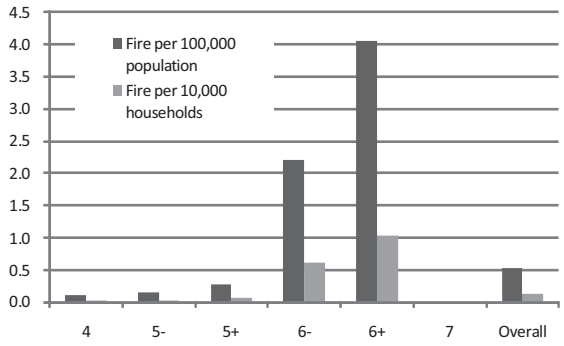

Fig. 8.1-1 Relation between fire break-out ratio and seismic intensity

Table 8.1-2 Seismic intensity, number of fire and fire break-out ratio

Seismic intensity	Population	Number of households	Number of fire	Fire per 100,000 population	Fire per 10,000 households
4	11,156,088	4,225,871	12	0.108	0.028
5−	19,042,953	8,292,245	31	0.163	0.037
5+	20,092,544	8,381,820	56	0.279	0.067
6−	4,254,959	1,543,580	94	2.209	0.609
6+	3,115,586	1,213,129	126	4.044	1.039
7	74,938	23,441	0	0.000	0.000
Overall	59,928,945	24,482,678	320	0.534	0.131

And the distribution of seismic intensity, number of fires and municipalities damaged by tsunami are geographically shown in Fig. 8.1-2.

Total data of the maximum seismic intensity by municipalities is based on the reports on seismic intensity released on May 30 and April 25, 2011 by the Japan Metrological Agency (JMA) of MLIT.

For this totaling, the municipalities in the prefectures which seismic intensity were 5 lower (5-) or more are included and the municipalities where seismic intensity has not been obtained or not yet been investigated are excluded from this totaling.

In only one area where seismic intensity 7 was observed, however, no fire was reported. The tendency that the higher the seismic intensity, the higher the fire break-out ratio, is observed in the municipalities where seismic intensity 6 lower (6-) or less was recorded.

In the cases of the 1995 Hyogo-ken Nambu (Kobe) earthquake and the 2004 Niigata-ken Chuetsu earthquake, in which seismic intensity 7 were recorded, fire ratio per 10,000

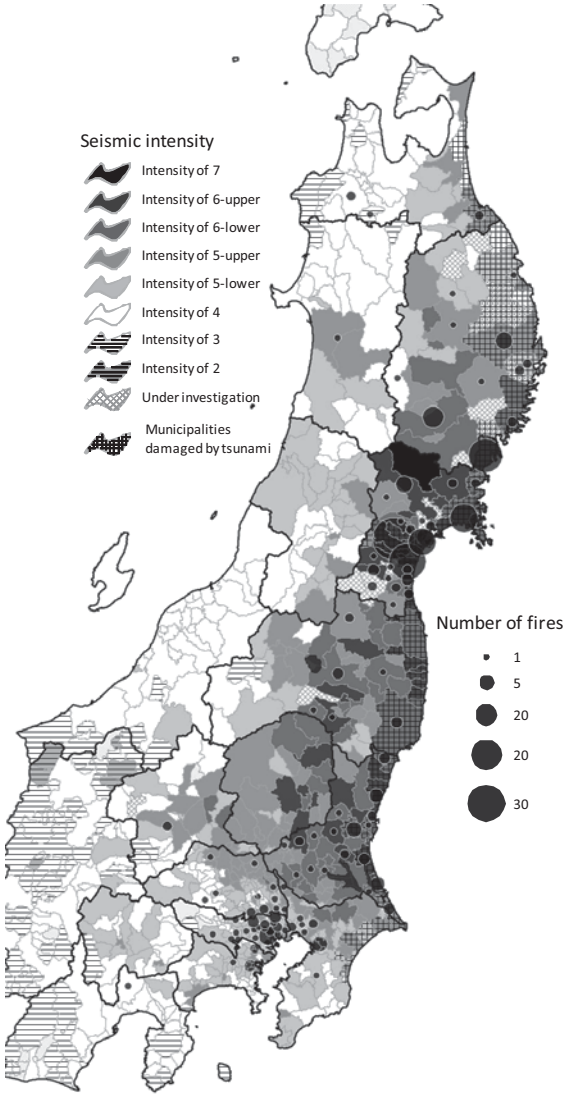

Fig. 8.1-2 Distribution of seismic intensity, number of fires and municipalities damaged by tsunami

households was 2~6 cases, but as for the 2011 Tohoku earthquake, the fire break-out ratio has become lower than the ratio for the 1995 Hyogo-ken Nambu earthquake.

However, in the areas of seismic intensity 6 upper (6+) in 2004 Chuetsu Earthquake, the ratio was around 0.7. Therefore, fire break-out ratio of 1.0 in the area of seismic intensity 6 upper of this earthquake is regarded as the same or a little higher value. The principal reason why the ratio of this earthquake is the same or a little higher, may be due to that many fires broke out in the damaged area by tsunami.

8.2 Damage by Fire due to Tsunami

There should be a distinction between fire occurred in areas damaged by tsunami (hereinafter referred to "tsunami fire") and fire occurred in other areas (hereinafter referred to "earthquake fire"), however at present, detailed information about the fire scene are not provided. Therefore, this report do not distinguish tsunami fire from earthquake fire out of the 345 fires.

Table 8.2-1 Number and break-out ratio of tsunami fire

Seismic intensity	Population	Number of households	Area of tsunami invasion [km^2]	Number of fire	Number of fire per 1km2 area of tsunami invasion	Fire per 100,000 population	Fire per 10,000 households
4	86,147	32,875	14	0	0.000	0.000	0.000
5−	207,519	73,107	16.5	3	0.182	1.446	0.410
5+	680,002	252,323	44.5	13	0.292	1.912	0.515
6−	1,492,701	557,650	280.5	68	0.242	4.556	1.219
6+	1,580,722	660,780	179	108	0.603	6.832	1.634
Not available	122,413	45,838	27	21	0.778	17.155	4.581
Total	4,169,504	1,622,573	561.5	213	0.379	5.109	1.313

Therefore, it is assumed the fires reported in the municipalities damaged by tsunami as tsunami fires and the fires reported in other municipalities as earthquake fires. The features of each fire on fire occurrence circumstance will be reported. Table 8.2-1 illustrates the list of number and break-out ratio of tsunami fire. The data has been acquired by totaling of the number of fire occurrence by the municipality areas of tsunami invasion.

Photo 8.2-1 Tsunami fire at an elementary school (Ishinomaki city, Miyagi prefecture)

It would be said that the features of tsunami fire which was reported in damaged area by tsunami, the area of fire spread extended to wider area where the

debris of buildings etc and automobiles which drifted and crashed would become cause of fire and fire spreading route.

Ishinomaki, one of the coastal cities of Miyagi prefecture, had huge damage due to tsunami and also had large fire that spread widely. As for the investigation soon after the earthquake disaster, the joint survey team could not find any information about the initiation of the fire; however, the team identified the range of fire spread.

Photo 8.2-1 shows a fire scene of an elementary school building located at about 1 km from the coast. Almost all of the 3-story school building had been burnt by the flame flared up from cars, combustible debris and oil and so forth that drifted and accumulated by tsunami in the schoolyard in front of the building.

Building at a port was one of the most damaged buildings by tsunami with not only tidal wave but also debris, cars and ships and so forth drifted by tsunami (Photo 8.2-2 and 8.2-3). Several hundred automobiles which have been parked in a parking zone, being drifted to a port warehouse by the tsunami, caused fire at the place where it accumulated.

The cause of the fire is unclear, but it is assumed that the car collided severely each other, the gasoline tank of the cars were damaged, and sparked by malfunction of the electrical system by the seawater. There was no spread of fire in the interior of the building, only the external wall has been damaged by fire.

Photo 8.2-4 shows the fire at a coastal village after several hours of tsunami invasion. The fire continued for

Photo 8.2-2 Tsunami fire at a port warehouse (Sendai city, Miyagi prefecture)

Photo 8.2-3 Vehicle fire due to tsunami at a parking lot (Iwanuma city, Miyagi prefecture)

Photo 8.2-4 Fire at a site of 8 buildings due to tsunami (Noda-village, Iwate prefecture), Courtesy of Noda-village

over 12 hours. Firefighters could not access to the site because the road had been destroyed by the tsunami.

8.3 Damage by Fire due to Earthquake Motion

Concerning the fires reported in the municipalities which did not have the damage of tsunami, the feature of fire occurrence circumstance as an earthquake fire is shown below.

Major cause of the fire was heat sources contacting surrounding combustibles with the earthquake motion and electric fires at the recovery of power supply from power failure and misuse of the candle which was used for the light in the midst of blackout nights which were also seen as the past cases.

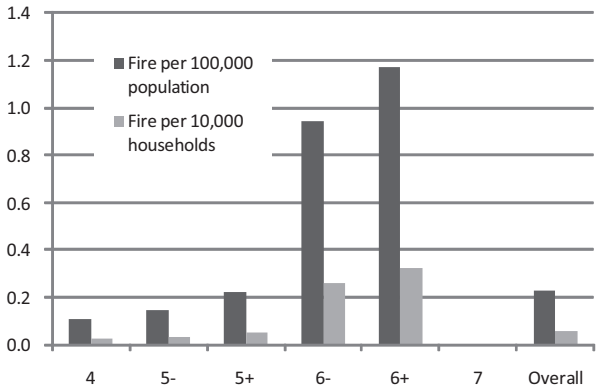

Fig. 8.3-1 Relation between break-out ratio of fire due to earthquake motion and seismic intensity

Table 8.3-1 Number and break-out ratio of fire due to earthquake motion

Seismic intensity	Population	Number of households	Number of fire	Fire per 100,000 population	Fire per 10,000 households
4	11,069,941	4,192,996	12	0.108	0.029
5−	18,835,434	8,219,138	28	0.149	0.034
5+	19,412,542	8,129,497	43	0.222	0.053
6−	2,762,258	985,930	26	0.941	0.264
6+	1,534,864	552,349	18	1.173	0.326
7	74,938	23,441	0	0.000	0.000
Overall	55,881,854	22,905,943	128	0.229	0.056

The relation between seismic intensity and break-out ratio of fire due to earthquake motion is shown in Fig. 8.3-1 and Table 8.3-1. Mass media have reported intensively fire due to tsunami, but many fire cases due to earthquake motion were also identified by this data. Some building fires were presented in the following.

Photo 8.3-1 shows a house fire scene of one victim in an inland rural

Photo 8.3-1 Fire scene of a house (Oushu city, Iwate prefecture)

district. The fire broke out not soon after the mainshock but at 10 pm of the same day. The cause of the fire has not been identified clearly, but, it is thought to be by the spark or hot exhaust gas leaked from the gap of smoke duct of a boiler for heating and bathing, due to earthquake motions.

Photo 8.3-2 shows a factory building fire in which half of the building burned. The cause of the fire is assumed to be ignition by falling of fluorescent light on the ceiling to the floor where the thinner spilled due to earthquake motions by the mainshock.

Photo 8.3-3 shows another house fire case in which two wooden houses were completely burnt out and three houses were partly burnt. The cause of fire is assumed to be misuse of candlelight for lighting in the midst of power failure on the night of the next day of the mainshock.

For a condominium fire, one case has been investigated: the fire broke out when electricity supply has been recovered at the night of the next day of the mainshock. The fire broke out on the 7th floor of a 17-story medium scale condominium. The residents of the room of fire origin were absent at the time, but some neighbors were aware of the fire and informed the fire station. Because of early suppression by firefighters, there was no spread of fire to the upper floor and the next rooms (Photo 8.3-4).

Photo 8.3-2 Fire scene at a factory building (Oushu city, Iwate prefecture)

Photo 8.3-3 Fire scene at a house (Oushu city, Iwate prefecture)

Photo 8.3-4 Fire scene at a condominium (Sendai city, Miyagi prefecture)

References

8.1-1) FDMA, MIC: http://www.fdma.go.jp/bn/higaihou/pdf/jishin/109.pdf (in Japanese, accessed September 1, 2011)

8.1-2) Editorial Committee for the Report on the Hanshin-Awaji Earthquake Disaster: Report on the Hanshin-Awaji Earthquake Disaster, Building Series Volume 6, Fire Damage and Civil Activities, Damage to Information Systems, AIJ, ISBN: 4-8189-2006-1, pp.51, October, 1998 (in Japanese)