Survey Report:

The Earthquake in Ōsaka-Fu Hokubu on 18 June 2018 and its Ensuing Disaster

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[Received July 8, 2018; accepted July 13, 2018]

An M6.1 earthquake occurred in the northern part of Ōsaka-fu (Osaka Prefecture) on June 18, 2018, with many areas in the Kinki region experiencing intense shaking. In Ōsaka City and Takatsuki City seismic intensity 6 lower was observed, resulting in 4 deaths, 15 people sustaining serious injuries, 419 people sustaining minor injuries, 10 completely destroyed residence, 181 partially destroyed residences, and 32,989 residences partially damaged (as of July 17, 2018). There were 339 cases of people being trapped in elevators. At most, approximately 1700 people were evacuated. While there were no derailment incidents on the Shinkansen or local train lines, service was suspended on most railways. Following this earthquake, Ōsaka-fu took the decision to apply The Disaster Relief Act. Response was then enacted by the government local public bodies, and the private sector.

Keywords: northern Ōsaka-fu earthquake, JMA seismic intensity 6 lower, urban earthquake disaster

1. Overview of Earthquake

On 18 June 2018 at 7:58 (Japan Standard Time (JST), same hereinafter), an earthquake with an M_{JMA}6.1 (Mw5.6) struck northern Ōsaka-fu (34.5°N, 135.4°E, 13.0 km depth, **Fig. 1**). Japan Metrological Agency (JMA) seismic intensity 6 lower was observed in Ōsaka-fu, in Ōsaka-shi (Kita-ku), Takatsuki-shi, Ibaraki-shi, Mino-shi, and Hirakata-shi (total population 1,301,386: 14.7% of Ōsaka-fu's total population of 8,826,303). Seismic intensity of 5 upper was observed in Ōsaka-fu, in Ōsaka-shi (Miyakojima-ku, Higashi-yodogawa-ku, Asahi-ku, Yodogawa-ku), Neyagawa-shi, Suita-shi, Settsu-shi, Katano-shi, Shimamoto-cho, and Toyonaka-shi (total population 1,756,418: 19.9% of Ōsaka-fu's total population of 8,826,303) and in Kyōto-fu, in Kyoto-shi (Nakakyō-ku, Fushimi-ku, Saikyo-ku), Yawata-shi, Kumiyama-cho, Kameoka-shi, Nagaokakyō-shi, and Ōyamazaki-cho (total population 810,000: 31.2% of Kyoto-fu's total population of 2,595,490) [1–3].

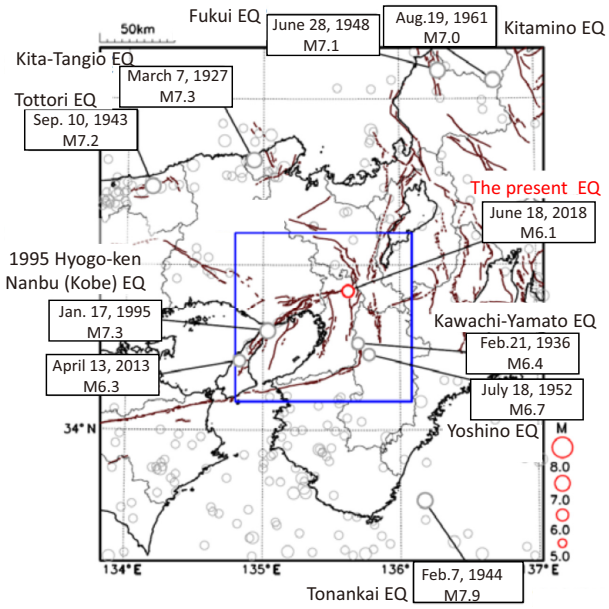

Fig. 1. Epicenters of events from Feb. 1, 1923 to 09:00 Jun. 18, 2018, M ≥ 5.0, depth ≥ 100 km. Major events are noted by a markup balloon with their date and magnitude (modified from JMA (2018) [1]).

Following this M6.1 earthquake, there was an M4.1 earthquake (max. seismic intensity 4) on June 19 at 00:31, an M4.0 earthquake (max. seismic intensity 3) on June 23 at 23:08, and as of 13:00 on June 25, over 40 earthquakes seismic intensity 1 and above (seismic intensity 4: 1, seismic intensity 3: 3, seismic intensity 2: 11, seismic intensity 1: 24). No tsunami were generated by these earthquakes [1].

2. Overview of Casualties and Damage

2.1. Casualties

The earthquake inflicted significant casualties: 4 fatalities in Ōsaka-fu, serious injuries to 15 people in Mie, Kyoto, Ōsaka and Hyōgo prefectures, as well as minor

injuries to 419 people in the above prefectures and also Shiga, Nara and Tokushima prefectures, totaling 434 casualties (as of 14:00 on July 17, 2018) [4].

2.2. Building Damage

As of 14:00 on July 17, 10 completely destroyed and 181 partially destroyed houses were counted in Ōsaka-fu A total of 32,989 partially damaged houses in Osaka (30,524), Kyoto (2,434), Hyōgo (4) and Nara (27) prefectures was recorded. The number of damaged residential houses may increase with surveys that are being conducted to assess damaged houses for the purpose of issuing Disaster Victim's Certificate (*risai shomeisho*) to affected people. There were three instances of fires caused by the earthquake in Ōsaka-fu, and four in Hyōgo prefecture. As of 16:00 on June 18, all of these fires have been extinguished [4].

2.3. Other Damage

The earthquake caused damage to electricity, gas, water and telephone services, resulting in outages. About as many as 170,000 homes, mainly in suburban Ōsaka, experienced an electrical blackout, but power was restored by 10:43, approximately 3 hours after the earthquake [5]. While gas service in Ōsaka-fu was stopped for 111,951 households in Takatsuki-shi, Ibaraki-shi, Settsu-shi and Suita-shi, services resumed completely by June 24 [6]. There were 339 cases of people trapped in elevators. The number of elevators experiencing emergency shut-downs was approx. 10,000. While there were no derailments on the Shinkansen (bullet train) line or local rail line, 8 Tōkaidō Shinkansen trains, 3 Sanyō Shinkansen trains, 153 JR West local trains, and 81 trains run by private railway companies were stopped on June 18. Service was resumed the same day [7].

3. Overview of Response

3.1. Response by National and Local Governments

The national government established a response office in the prime minister's office on June 18 at 8:00, immediately after the occurrence of the M6.1 event, convening an emergency team composed of the directors of the respective ministries and agencies. Following the designation by the prime minister at 8:03. and a prime minister's press conference at 8:57, "the Prime Minister disaster management meetings at the ministerial or high-ranking senior official level regarding the 2018 earthquake with a hypocenter in northern Ōsaka-fu" was convened at 15:00.

Ōsaka-fu established a Major Disaster Management Headquarters at 7:58, and after dispatching an initial emergency survey team (2 prefectural employees) at 9:10, it convened its first and second major disaster management headquarters meetings at 9:30 and 13:48 respectively, and began assessing the damage distribution and severity. Because a large number of casualties were reported and many people were in danger of being harmed, Ōsaka-fu decided at 17:30 to apply The Disaster Relief Act to twelve cities and one town (Ōsaka-shi, Toyonaka-shi, Suita-shi, Takatsuki-shi, Moriguchi-shi, Hirakata-shi, Ibaraki-shi, Neyagawa-shi, Mino-shi, Settsu-shi, Shijōnawate-shi, Katano-shi, Mishima-gun-shimamoto-chou.

Local public bodies and local governments in the Kansai region – such as Kyōto-fu, Hyōgo prefecture and Nara prefecture – established Disaster Alert headquarters similar to the one in Ōsaka-fu. In Kyōto-fu, where significant damage was recorded, this was converted into a Disaster Management headquarters at 10:00, which continued with the response actions.

Subsequently, evacuation shelters were opened in Ōsaka-fu, Kyōto-fu and Hyōgo prefecture, with as many as 1,785 people leaving their home and moving to 346 shelters in Ōsaka-fu (as of June 19, 07:30 a.m.) and 42 people evacuating to 8 shelters in Kyōto-fu (as of June 19, 15:00). As of June 25, one week after the disaster occurred, there are 467 evacuees in Ōsaka-fu [4].

3.2. Response by Earthquake Investigation Agencies

The Headquarters for Earthquake Research Promotion convened an interim earthquake investigation committee meeting at 16:00 on June 18, and announced its assessment of the earthquake in Ōsaka-fu Hokubu [8].

On June 14, the National Research Institute for Earth Science and Disaster Resilience (NIED) established a crisis response website and used its real-time seismic damage estimation system (preliminary version) to estimate the distribution of completely destroyed buildings (June 15/16) [9].

4. Features of This Disaster, and Upcoming Issues

The earthquake that struck Ōsaka-fu Hokubu corresponds to earthquakes that occur at an approx. monthly frequency in Japan. For example, the number of earthquakes occurring in Japan and its vicinity of M6.0 or above is 1.4, amounting to approx. 17 times per year (average value for 84 years between 1924–2007). In turn, according to the JMA's database (since 1923), this was the first instance of an earthquake greater than JMA Seismic intensity 6 lower in Ōsaka-fu.

Past earthquakes that caused damage in Ōsaka-fu include the earthquake in 1596 with an M7 1/2 known as the Keicho-Fushimi Earthquake. Causing damage over a widespread area within Ōsaka-fu, this earthquake claimed more than 600 lives in Sakai (currently the area around Sakai-shi). Furthermore, in the 1936 Kawachi Yamato Earthquake (M6.4), there were 8 fatalities within Ōsaka-fu, and fissures in the ground were observed as well as sand volcanoes and welling of water [5]. More recently, in the 1995 Hyōgo-ken Nanbu, Kobe, Earthquake, JMA

seismic intensity 4 and 5 were observed in Ōsaka Chuo-ku and Kyōto-shi, Nakagyou-ku respectively.

In the vicinity of the epicenter of the present earthquake is the Arima-Takatsuki fault zone that runs east to west, and the Ikoma fault zone and Uemachi fault zones which extend from south to north. No surface geodetic or geomorphic evidence indicating surface ruptures was reported as is usually the case for an M6 class earthquakes occurring at a depth of 10 km or deeper.

Although the hypothesis cannot be rejected that this earthquake constitutes activity related to these fault zones, it will be necessary to conduct further investigations based on results of upcoming observations to gain a clearer picture [10].

This earthquake occurred in an urbanized area with a highly dense population, even for Japanese standards. The population of Ōsaka-shi (2,721,728) [2] during the day is 1.31 times greater than that of the nighttime population; in particular, for the Kita-ku district where JR Ōsaka station is located and Chuo-ku where many offices are located, the daytime population is 3.33 times and 4.88 times greater [11], respectively. Due to the earthquake occurring just before 8:00 on a Monday morning during the commuter and school rush-hour, the impact was exacerbated.

Because of commuting time, interruptions and delays of trains caused congestion on the roads, which were overflowing with people walking to their destination. Train interruptions continued throughout the day, mainly for JR, with reports that some 5.8 million people were affected.

Among the four fatalities (a 9-year-old girl and an 80-year-old male) were caused by a collapse of a concrete-block wall, while two were caused by falling furniture (bookshelves) or the falling books inside homes (85- and 66-year-old males). The 9-year-old girl was killed by a collapsing concrete-block wall next to the school's swimming pool while walking to school, providing a stark reminder of the importance of safety measures for non-structural elements. However, there is a high possibility that this concrete-block wall was in violation of the building code.

Since the 19th, one day after the earthquake struck, disaster volunteer centers were opened in various cities around suburban Ōsaka-fu, with efforts focused on listening to the support needs of local residents.

This is an earthquake disaster in a major urban area, and in the coming months there will be a pressing need to analyze the damage, the impact and the response in order to learn vital lessons for responding to major earthquake disasters that may strike the Tokyo metropolitan area in future. To enhance social resilience to a seismic disaster, we suggest to install a simple little seismometer in buildings for post-mortem analyses of collapsed or heavily damaged buildings. A dense network would also favor a better knowledge on site conditions [12].

Acknowledgements

The present work is partially supported by Tokyo Metropolitan Resilience Project of National Research Institute for Earth Science and Disaster Resilience (NIED). The work is partially supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) of Japan, under its Earthquake and Volcano Hazards Observation and Research Program. R.K. is supported by JSPS/MEXT KAKENHI Grant Numbers JP26242031. We thank Joel Challender of NIED for his English editing of the present manuscript. Danijel Schorlemmer improved the manuscript.

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