



## 2016 Kumamoto Earthquake Survey Report (Preliminary)

On 14 and 16 April 2016, earthquakes occurred in the middle of Kyushu Island, in southwestern Japan, measuring a magnitude 7 (the highest level) on the seismic intensity scale of the Japan Meteorological Agency (JMA). The quakes caused 49 deaths in Kumamoto prefecture and 7,996 houses were totally destroyed in Kumamoto and Oita Prefectures. The direct economic losses are estimated at ¥2.4–4.6 trillion (US\$24–46 billion). ADRC gave a preliminary report on the Kumamoto earthquakes and the damage they caused based on the official reports made by JMA and cabinet office, together with the results of an ADRC field survey conducted on 18-21 May. ADRC will continuously make recommendations on DRR/DRM by continuing to investigate the Kumamoto Earthquakes.

### 1. Overview

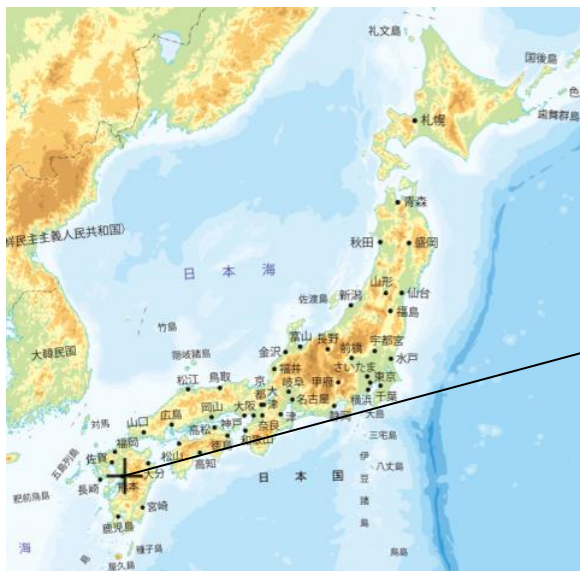
#### 1.1 Outline of the 2016 Kumamoto Earthquakes

The first quake (foreshock) occurred on 14 April 2016 at 21:26 in Kumamoto Prefecture. The epicenter was at 32° 44.5' N, 130° 48.5' E, at a depth of about 11 km below ground and the magnitude measured 6.5 (Mj). An earthquake with a JMA seismic intensity of 7 was recorded in Mashiki Town.

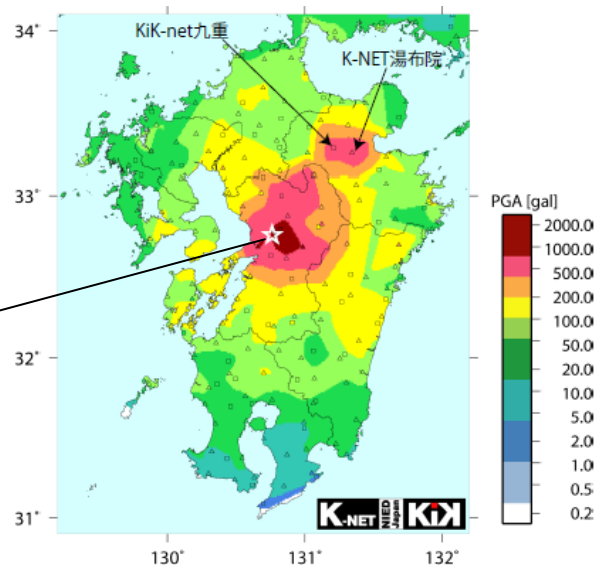
About 28 hours later, the second quake (main shock) occurred on 16 April 2016 at 01:25 in Kumamoto Prefecture. The epicenter was 32° 45.2' N, 130° 45.7' E at a depth of about 12 km, with the magnitude measuring 7.3 (Mj). A JMA seismic intensity of 7 was recorded in Mashiki Town and Nishihara Village. Mj7.3 is the same magnitude recorded during the Great Hanshin-Awaji Earthquake in 1995. Also, this was the first time that two successive magnitude 7 earthquakes were recorded back-to-back in Japan. These Kumamoto Earthquakes are considered to have been connected, with the foreshock recorded at the northern end of the Hinagu fault, and the main shock recorded at the Futagawa fault.

Source: Headquarters for Earthquake Research Promotion

[http://www.static.iishin.go.jp/resource/monthly/2016/2016\\_kumamoto\\_3.pdf](http://www.static.iishin.go.jp/resource/monthly/2016/2016_kumamoto_3.pdf)



Source: Geospatial Information Authority of Japan



Source: National Disaster Institute for Earth Science and Disaster Resilience



## 1.2 Outline of Damages

### 1.2.1 General

#### **Human Casualties**

The total number of deaths in Kumamoto Prefecture was 49, with 360 severely injured and 1,258 slightly injured as of 24 May 2016.

Table 1 Human Casualties (persons)

Pref.	Deaths	Severely Injured	Slightly Injured
Fukuoka	0	1	17
Saga	0	4	9
Kumamoto	49	360	1,258
Oita	0	4	23
Miyazaki	0	3	5
<b>Total</b>	<b>49</b>	<b>372</b>	<b>1,312</b>

Source: Emergency Disaster Response Headquarters

Note: Another 20 deaths are considered to be quake-related, and 58 injured persons in Kumamoto are have not yet been classified.

#### **Building Damage**

Housing damage statistics show that across seven prefectures, there 7,996 houses totally destroyed, 17,886 houses half destroyed, and 73,035 houses partially destroyed as of 24 May 2016. Most of the totally destroyed buildings were in Kumamoto Prefecture, just as were most of the human casualties. As many as 248 public buildings were damaged in Kumamoto Prefecture alone.

The five municipalities of Kumamoto Prefecture have resumed operations at locations outside of their city halls due to damage (as of 23 May 2016).

- Yatsushiro City : To Sencho branch office
- Hitoyoshi City : To City hall Annex, Sport Palace, and the Culture Palace
- Uto City : To Citizen Gymnasium
- Ozu Town: To Nearby Public Facilities
- Mashiki Town: To Central community center

Table 2 Building Damage (Buildings)

Prefecture	Housing			Non-Residential Buildings		Fires
	Totally destroyed	Half destroyed	Partially destroyed	Public buildings	Others	
Yamaguchi			3			
Fukuoka		1	230		1	
Saga			1		2	
Nagasaki			1			
Kumamoto	7,994	17,818	70,609	248	660	16
Oita	2	45	2,171		8	
Miyazaki		2	20			
<b>Total</b>	<b>7,996</b>	<b>17,866</b>	<b>93,035</b>	<b>248</b>	<b>671</b>	<b>16</b>

Source: Emergency Disaster Response Headquarters

**Lifelines**

Table 3 Lifeline Damage and Recovery

	Peak damage	Recovery situation
Electricity	474,000 units blackout (16 Apr.)	Mostly restored as of 20 Apr., full restoration as of 27 Apr.
Gas	105,000 units outage (16 Apr.)	Full restoration at 30 Apr.
Water	445,857 units water outage (16 Apr.)	136 units at 23 May, except in totally destroyed houses
Oil	104 Service Stations closed	More than 90% working as of 24 May

Source: Emergency Disaster Response Headquarters

**Transportation**

Table 4 Transportation System Damage and Recovery

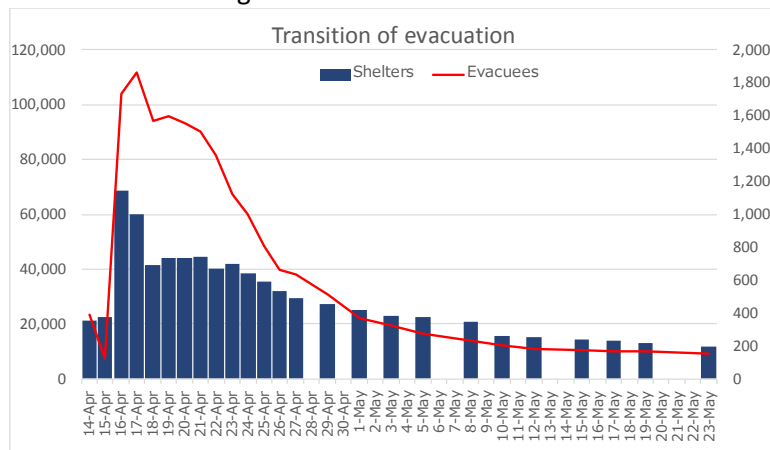
	Peak damage	Recovery situation
Highways	Many road surfaces damaged, 33 sections of bridge damaged, landslides	All traffic regulations have been canceled as of 29 April
National roads	Displacements and landslides in 15 locations	As of 24 May, seven sections are blocked, bypass route available
Railways	Much damage to private railway tracks, facilities, and stations	As of 24 May, service remains suspended on two lines
Shinkansen bullet train	Deadhead train was derailed, tracks and Kumamoto station were damaged	Full restoration as of 27 April
Airports	Kumamoto airport was closed on 16 Apr	90% passenger flights are in service as of 19 May
Ports	Four major ports affected	Emergency rehabilitation (24 May)

Source: Emergency Disaster Response Headquarters

**1.2.2 Evacuation Situation**

Affected municipal governments provided gymnasiums and other public buildings for use as public shelters for affected residents who could not live in their damaged houses in Kumamoto, Oita, Nagasaki, and Fukuoka Prefectures. The peak numbers recorded were 855 shelters and 183,882 evacuees as of 17 April. There were 198 shelters and 8,911 evacuees as of 23 May. Public shelters except Kumamoto Pref. were closed by 16 May.

Figure 1 Evacuation Situation



Source: Emergency Disaster Response Headquarters



### 1.2.3 Other Damage: Landslides

Many landslides occurred due to the earthquakes. As many as 136 sediment-related disasters such as landslides and debris flows were recorded, killing nine people. In addition, 494 river embankment locations were damaged.

([http://www.bousai.go.jp/updates/h280414jishin/pdf/h280414jishin\\_27.pdf](http://www.bousai.go.jp/updates/h280414jishin/pdf/h280414jishin_27.pdf))

### 1.2.4 Economic Losses

The direct economic losses are estimated at 2.4-4.6 trillion yen (22.4-43.0 billion USD). It is a scale behind to the Great Hanshin-Awaji Earthquake in 1995.

Table 5 Direct Economic Losses Caused by Past Earthquakes in Japan

Past Earthquake in Japan	Source	Direct Economic Losses	
		¥ trillion	US\$ billion
2016 Kumamoto Earthquakes	Cabinet Office analyst	2.4-4.6	24-46
2011 Great East Japan Earthquake	Cabinet Office for Disaster Management	16.9	169
	Cabinet Office analyst	16-25	16-25
2004 Chuetsu Earthquake	Niigata Prefecture	1.7-3	17-30
1995 Great Hanshin-Awaji Earthquake	National Land Agency, Hyogo Prefecture	9.6-9.9	96-99

Source: "Ministerial Conference Materials on Monthly Economic Report," 23 May 2016, Cabinet Office (<http://www5.cao.go.jp/keizai3/getsurei/2016/05kaigi.pdf>), Calculated as 1USD = 110 yen.

### 1.3 Comparison with Recent Earthquake Disasters

A comparison of the earthquakes that occurred in Japan and ADRC member countries in recent years reveals that the magnitude of shaking in the 2016 Kumamoto Earthquakes is same as that experienced during the 1995 Great Hanshin-Awaji Earthquake, which was an inland active fault-type earthquake. However, it caused only 49 deaths because the epicenters were not in Kumamoto City, the prefectural capital and the second largest city on Kyushu Island. A comparison against the 2015 Nepal Earthquake and 2009 China Sichuan Earthquake, however, shows that while those earthquakes caused more casualties, the Kumamoto Earthquakes will result in much higher direct economic losses than were caused by the Nepal Earthquake.

Table 6 Direct Economic Losses Due to Recent Earthquakes in Asia

	Magnitude (M)	Deaths (persons)	Direct Economic Losses (billion USD)
2016 Kumamoto Earthquakes	7.3	49	22.4-43.0
2015 Nepal Earthquake	7.8	8,964	5
2011 Great East Japan Earthquake	9.0	19,846	145-227
2009 China Sichuan Earthquake	8.0	87,476	85
2004 Sumatra Earthquake and Indian Ocean Tsunami	9.1	226,408	9.3
1995 Great Hanshin-Awaji Earthquake	7.3	6,434	87-90

Source: Cabinet Office, EM-DAT, Calculated as 1USD = 110 yen.



## **2. ADRC Kumamoto Earthquake Field Survey Overview**

### **2.1 Outline**

Dates:	18-21 May 2016
18 May afternoon:	Kobe to Kumamoto (overnight at Kumamoto-eki-mae)
19 May all day:	Field survey around Kumamoto station, Kumamoto Castle, Kumamoto City Hall, Aso Ohashi (Red Bridge), Mashiki Town, Uto City Hall, and Aso city (overnight in Aso city)
20 May all day:	Field survey of Aso city area, Aso Shrine, Ozu Town Disaster Volunteer Center, Mashiki Town. Courtesy call on Prof. Takagi, Kumamoto Gakuen University (overnight in Kumamoto city)
21 May morning:	Field survey of liquefaction in the Hiyoshi area, southern Kumamoto. Afternoon: Kumamoto to Kobe
Survey personnel:	3 personnel (former ADRC Executive Ddirector, Dr. Ogawa, Mr. Nakao, and Mr. Arakida)
Transportation:	Shinkansen: Kobe-Kumamoto, Rental car: Field survey

### **2.2 Overview of ADRC Kumamoto Earthquake Field Survey**

The survey team visited mostly affected area in Kumamoto prefecture including Mashiki town, Kumamoto city, Uto city, Ozu town, and Aso city. The team surveyed the overall damages, and conducted interviews at Kumamoto Castle, Kumamoto City Hall, Aso Yamamoto Farm, Mashiki Town, and Ozu Town Disaster Volunteer Center.

#### ***Overview of the Affected Areas at Time of Survey***

The general impression of the affected area was that the damage was similar to the massive damage caused by the Great Hanshin-Awaji Earthquake, in particular, those in Mashiki Town, which experienced two separate magnitude 7 earthquakes. On the other hand, the area around Kumamoto railway Station and downtown Kumamoto seemed to have been restored to their pre-earthquake conditions, and hotels were nearly full due to recovery-related visitors. Uchinomaki Onsen (hot springs) at the Mount Aso has gradually reopened, and was at full occupancy for recovery-related visitors as well.

Generally, major damage was identified above and along the active faults that moved. The ground separated from north to south, and the area between the two cracks was depressed. This phenomenon was quite different from what has been seen in past earthquakes in Japan. Private houses and pump stations seemed not to have any abnormalities, and the pump was operating normally.

The speed of recovery of civil engineering structures and lifeline looked quick ,which could be explained by the limited fact that the damages in the city of Kumamoto, centre of the prefecture, and those to the roadways had been limited to some areas. On the other hand, some city halls remained out of use due to earthquake damage. There was remarkable liquefaction damage along the original Shiorakawa River around Hiyoshi, Kumamoto city, but



the affected residents had not been previously aware of the old land-use style and liquefaction risks.

### ***Key perspectives of the initial field survey***

This survey assessed the extent of damage and recovery, with particular focus on the following points.

#### **2.2.1 Human resource development for DRR**

One of the focus of this initial survey was placed on human resource development for DRR at local level, since ADRC has long been carrying out many projects for this purpose.

In the case of Kumamoto earthquake, direct supports for the affected population has been handled by local government officials in the quake hit areas. Local government officials and volunteers from all over Japan have joined them in organizing and supporting shelter operations, sorting and delivery of relief supplies, house damage certification, classroom reopenings, and public health and nutrition guidance.

The Social Welfare Council of Ozu Town, whose population (30,000), located in a suburban dormitory town of Kumamoto, with growing population opened a disaster Volunteer Center on 22 April, six days after the quake. Volunteers cleaned up private homes alongside victims, providing support to help them resume their lives. At the peak, as many as 130 volunteers were received per day and the number has decreased to 10 volunteers (as of 27 May) since good progress has been made on rubble processing and requests for assistance have decreased.

One of the interviewed persons had taken two training courses organized at Disaster Research Institute, Kobe (DRI), which had been established after the Greta Hanshin Awaji earthquake. He indicated that the damages and indicated that the damage and response timeline following this disaster were in alignment with what he had learned at DRI, and stressed that the training courses thus proved helpful. Disasters can occur under a variety of circumstances. The lessons learnt of Kumamoto earthquake together with those of past disasters need to be shared to improve DRR human resource development training course, in close collaboration with the affected local governments.



Photo 1 Ozu Town Disaster Volunteer Center

#### **2.2.2 Housing damage assessments for rapid reconstruction**

More than 90,000 houses were affected by the earthquake. In Japan, local governments conduct "House Damage Assessment" to determine their degree of damage. In addition,

architects conduct “Post-earthquake Quick Inspection of Damaged Buildings” to assess safely to buildings to withstand aftershocks, while insurance companies conduct damage investigations for earthquake insurance payments. The post-earthquake quick inspection of damaged buildings began on 15 April in Mashiki and on 16 April in other municipalities, with the support of other local governments in Japan and private architects. It is important that the necessary inspections are quickly and comprehensively performed after a disaster, and that greater efforts are made to widely disseminate information about the purpose of these systems.

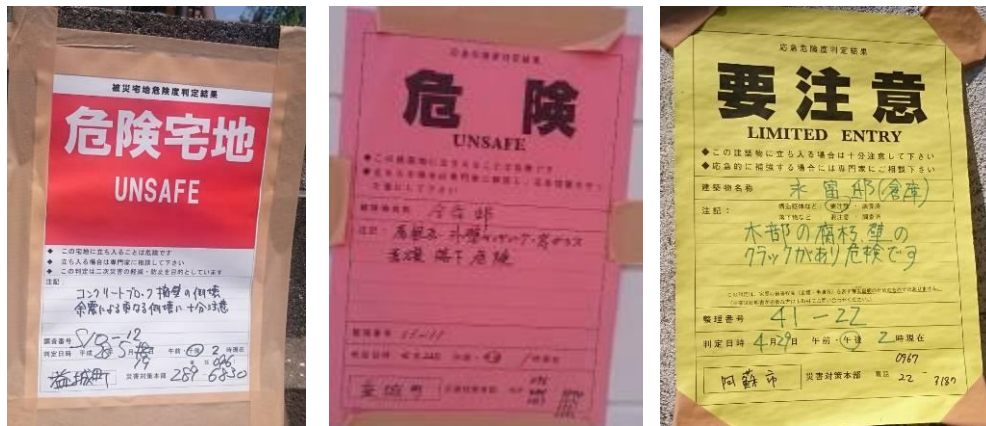


Photo 2 Emergency safety evaluation for buildings and urbanized sites

### 2.2.3 Affected cultural heritage and possibilities of creative reconstruction by tourism

Kumamoto Castle, a symbol of Kumamoto Prefecture, which was built in the 16th century, has been designated as an important cultural property Japan. Its walls and turret were severely damaged by the earthquakes. It is feared that it will take a lot of money and time to repair the damage. At Aso shrine, which is said to have been founded in the 3rd century BC, the tower gate and hall of worship were severely damaged. Other buildings that are not classified as historic buildings, were also damaged Aso Ohashi, Red Bridge, for example, which is regarded as a civil engineering heritage, was swept away by a large-scale landslide.

The Kumamoto Recovery and Reconstruction Experts Meeting (chaired by Makoto Iokibe) established by the Kumamoto prefectural government has announced an emergency proposal regarding basic reconstruction policies, entitled "Towards Creative Reconstruction from the Kumamoto Earthquakes." It proposes that the rehabilitation and reconstruction plan to be made by the prefecture include considerations for Kumamoto Castle reconstruction given its position as a tourism resource as well as efforts to strengthen public support for the seismic diagnosis and reinforcement of private houses . The report also proposes channels for learning about earthquake disasters and exposed active faults with the cooperation of relevant partners, and addresses future challenges, such as efforts to revitalize the local tourism industry for early reconstruction of the community.

There are several cases in which disaster-stricken areas became tourist' destination thus contributing to a participatory process of reconstruction involving local citizens. Japanese examples include the Disaster Reduction and Human Renovation Institution which was established after the Great Hanshin-Awaji Earthquake, and the Sanriku railway after the Great



East Japan Earthquake. Overseas examples include New Orleans after Hurricane Katrina and Volcano Pinatubo in the Philippines.



Photo 3 Damaged Kumamoto Castle and Aso Shrine

#### **2.2.4 Other**

Furthermore, ADRC would like to focus on the following points in the future.

##### ***Effective utilization of ICT in affected areas***

Affected local governments announced information regarding damage and support services several days after the main shock, but only individuals with a smart phone or other internet connection could access that information. Many evacuees only had access to TV or radio as their source of information. In addition, an emergency public bulletin published in Kumamoto City was published on 23 April, 7 days after the main quake. The case of Kumamoto will provide precious lessons to strengthen the community disaster management information infrastructure using ICT and other technology devices.

##### ***Evacuation process***

In Japan, for residents who are no longer able to live in their homes due to the effects of a disaster, local governments have designated nearby elementary and junior high school gymnasiums as public shelters in advance. In this case, there 855 shelters established and approximately 180,000 people evacuated at the peak. Because evacuees' privacy is very limited in the gymnasium, some affected people chose to use their private vehicles as their shelter even though there is a risk of "economy-class syndrome" (an increased risk of blood clots in the legs). On the other hand, there were also examples in this quake of support from the community in the form of tents, partitions made of paper, and efforts to take gender needs into consideration. Since examples exist both in Japan and abroad of evacuation approaches that are more comfortable for the elderly, of technologies and products for supporting evacuation measures, and of wide-area evacuation strategies, such tactics should be the subject of further examination in the future.





### 2.3 Future Focus of Research

Based on the results of this survey, ADRC would like to continue to investigate the major themes, and also to focus on the following points, to promote the sharing of lessons learned and past experiences with member countries.

- ***Sharing disaster experiences, disaster education***
- ***Evacuation approaches friendly to vulnerable people and challenges (possibilities for wide-area evacuation)***
- ***Possibility of disaster tourism for the reconstruction of affected areas***
- ***Impact on the supply chain of Kumamoto, Kyushu, and the Asian region***
- ***BCP formulation effects for companies, including local governments and small and medium-sized enterprises***
- ***Strengthening the local DRR information infrastructure using cutting-edge technology such as satellite imagery and ICT equipment***

#### Utilizing Lessons of the Great Hanshin-Awaji Earthquake to Support Recovery in Kumamoto

Local governments all across Japan sent support to Kumamoto after the earthquake to provide aid to the disaster-affected local governments which had themselves become victims of the earthquake. Hyogo Prefecture initiated various response measures after the Great Hanshin-Awaji Earthquake, which struck the region 21 years ago. Particularly notable is the Emergency and Rescue Team comprised of public school faculty and staff (known as EARTH) which was developed in 2000 based on the experiences of that earthquake. Under this program, as many as 176 faculty members, teachers, counselors and others have completed the Advanced Training Course for Instructors to promote DRR education (as of April 2016). EARTH regularly conducts DRR education and dispatches members to disaster-affected areas when disasters strike. They provided support after the Sumatra Earthquake, Sichuan Earthquake, and Great East Japan Earthquake and have been dispatched to other disaster sites within and outside Japan. Likewise, EARTH dispatched approximately 50 members on April 16 to assist immediately after the Kumamoto Earthquake. They have been providing ongoing support, including shelter management (mainly at schools serving as shelters), mental health care, the dissemination of disaster experiences and lessons learned, and the transmission of expertise accumulated over the course of their various disaster support efforts. In this way, valuable lessons have been shared with human resources throughout the prefecture, and these lessons are then passed on to disaster-affected sites.

ADRC would like to share information about these kinds of local government experiences and initiatives with local governments throughout Asia.



Explaining disaster responses to executives



Workshop on training session for faculty and teachers



Educational support provided after classes resume

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