

Related Effort - Structural Reconnaissance to Kumamoto Earthquake

1. Overview

On June 30th 2016, a team of Engineers and Researchers from New Zealand will travel to the city of Kumamoto, Japan, to gather site observations and data following the magnitude 6.2 and 7 earthquakes which struck north of the city in April.

The New Zealand team, will be working in conjunction with a Japanese based team, lead by Professor Maeda from Tohoku University and a team from Taiwan.

This page has been set up to share relevant information leading up to and following the reconnaissance visit and will continue to be updated.

The team will also produce a report of their findings following the trip which will also be shared here.



2. Background Information

Extracts from papers with relevant information are provided below, the full texts are also provided through links at the bottom of the extract.

Paper 1:

NZSEE 'Learning from Earthquakes' Mission: 2016 Kumamoto Earthquake, Japan Preliminary report on geotechnical and geological aspects of the 2016 Kumamoto Earthquake

Gabriele Chiaro^[1], Gavin Alexander^[2], Pathmanathan Brabhakaran^[3], Christopher Massey^[4], Junichi Koseki^[5], Surugu Yamada^[6] and Yadaï Aoyagi^[7]

1. 1. Introduction

At 21:26 JST (12:26 UTC) on April 14, 2016, a local magnitude M_j 6.5 (Japan Meteorological Agency - JMA, 2016) or moment magnitude M_w 6.2 (U.S. Geological Survey - USGS, 2016) earthquake hit Kyushu Region in Southern Japan (Figure 1). The epicentre of the earthquake was located in Mashiki Town, along the northern part of the Hinagu main active fault. It was the first earthquake to occur on the Island of Kyushu to register as M_j 7 (the highest possible level) on the JMA seismic intensity scale (IX-XII approximate equivalent rating on Modified Mercalli Intensity scale - MMI). In the following hours, there were over one hundred aftershocks, comprising a JMA M_j 6.4 (USGS M_w 6.0) earthquake that occurred at 00:03 JST on April 15, 2016. These earthquakes, however, proved to be foreshocks of the strongest event that occurred at 01:25 JST on April 16, 2016 (16:25 UTC, April 15). This earthquake of JMA M_j 7.3 (USGS M_w 7.0), was located under Higashi Ward of Kumamoto City (adjacent to Mashiki Town). The earthquake and associated surface fault rupture lead to lateral strike-slip displacement along the central part of Futagawa main active fault.

The focal mechanism associated with lateral strike-slip faulting and the relatively shallow depth of the hypocentres (7-12 km) played an important role on the severity and spatial distribution of damage in the affected areas. High vertical and horizontal accelerations were recorded by most of the KIK-NET and K-NET strong motion stations located in the proximity of the main active faults in Kumamoto Prefecture (Figure 1). During the two major earthquakes (which ones?), horizontal peak ground accelerations, exceeding 0.85g, were recorded in Mashiki Town. Damage to residential houses ranged from no damage in areas of low shaking or where houses had been recently constructed, to complete collapse, especially of the older traditional one-storey or two-storey timber houses, in the areas of strong shaking and surface fault rupture. In total several thousands of residential houses were reported to have been damaged or fully collapsed. The main areas affected was Mashiki Township, which appeared to be the worst-hit area. Numerous landslides took place across the mountains of Kyushu, the majority of which, occurred on slopes inside the Mount Aso caldera. The earthquake also caused considerable damage to roads, highways and rail transportation. Several bridges, including the famous Aso Bridge, were completely destroyed or were significantly damaged. Rupture along the main fault was mapped at the surface over several kilometres, from Mashiki Town (to the West) to Minami Aso Village (to the East). Many residents of Nishihara Village were evacuated over fears that a nearby earth-dam, damaged by fault rupture, could breach. In Kumamoto City Centre and in Mashiki Town, liquefaction took place along rivers, causing lateral spreading, differential settlements of the ground and riverbanks, sinking and tilting of buildings, foundation failures, cracks on roads, and disruption of water and sewage pipe networks. At the time of writing this report, the total number of reported deaths is 69, although some people are still missing. Based on newspaper reports, at least 10 of these deaths can be related to four landslides that occurred following the main earthquake on 16 April 2016.

The two main earthquakes were preceded by heavy rainfall a week before the events, and afterwards by heavy rainfall on the 21 April 2016. These rainfall conditions are typical for this time of year, but such rain may have contributed to the severity of the observed earthquake damage.

To gain valuable lessons for the 2016 Kumamoto Earthquake, the New Zealand Society for Earthquake Engineering sent a team of experienced geotechnical engineers and engineering geologists to investigate the earthquakes impacts in Kumamoto Prefecture. The reconnaissance team were on the ground from 7 May 2016 to the 14 May 2016. For the reconnaissance mission, the NZSEE team members were integrated within a Japanese investigation team comprising geotechnical engineers from the Universities of Tokyo and Osaka. This provided an invaluable learning experience, as it allowed: i) rapid access to the sites of interest; ii) key geotechnical/geological information to be gathered (otherwise available only in Japanese); iii) collection of soil samples for further geotechnical analyses; and iv) an opportunity for valuable technical discussions.

The survey trip was planned so that most of the relatively large geographical area affected by the earthquakes was covered on the ground. This allowed the team to observe and record the type and spatial distribution of the main hazards triggered by the earthquakes. Figure 2 shows the daily investigation routes visited on the ground and the main places of interest that were visited during the reconnaissance survey. A unique aspect of this reconnaissance mission is that the observations were made only three to four weeks after the main earthquakes, when the government and local authorities were still in the emergency response phase. Thus numerous earthquake impacts were observed "first-hand" by the team, before major repair work had been carried out.

This report provides a reconnaissance-level description of the types and extent of landslides and other ground damage triggered by the Kumamoto earthquakes of 14 and 16 April 2016, and some discussion about their effects and significance in the context of earthquake-induced ground damage in New Zealand. Such observations can therefore help to identify where similar hazards and impacts could occur in New Zealand, as well as to provide insights on how to mitigate against such hazards. Observations of building and infrastructure performance in response to the strong ground shaking also provided a unique opportunity to see how certain construction methods and materials performed.

This report builds on the two previous "In-Country Reports" by: i) describing in more detail the observations of earthquake ground damage made by the team; and ii) discussing the relevance and implications of these observations to New Zealand.

It should be noted that the observations and views expressed in this report are those of the NZSEE team. The team was helped greatly by Japanese colleagues to understand the background and context of the observed hazards and their impacts. However, the team's findings are based primarily on field observations and other information taken from published data and reports, news articles (available at the time of writing) and from discussions with Japanese colleagues. During the teams visit it was not possible to arrange meetings with the relevant Japanese government officials. The team therefore is not aware of the specific details relating to the government and local authorities response to the disaster.

The full text can be found at the link below:

Paper 2:

NZSEE 'Learning from Earthquakes Mission': Kumamoto Earthquake 2016, Japan

In-Country Report No 2 of 14th May 2016

Introduction

A 4 member team from the New Zealand Society for Earthquake Engineering, comprising Dr Gabriele Chiaro, Dr Chris Massey, Gavin Alexander and P Brabhakaran, left New Zealand on 6th May and arrived in Oita, Japan on the evening of 7th May 2016. The team joined Prof Junichi Koseki and three colleagues (Tamoko Sasaki, Naoya Nunokawa, Yudai Aoyagi) from University of Tokyo to survey damage around Aso City (Mt Aso volcanic caldera) on the 8th and 9th May. This was followed on the 10th to 13th May 2016 by further surveys of the earthquake damage around Aso city, Mashiki township and Kumamoto city, with two Japanese colleagues (Associate Prof Suguru Yamada and Yudai Aoyagi). The earthquake reconnaissance was concluded on the evening of Friday 13th May 2016, and the team is returning to New Zealand on 15th May 2016. The areas visited by the team are shown in Figure 1. This second In-Country Report summarises the observations of earthquake damage made by the team, which may be shared with the management committee and membership.

The full text can be found at the link below:

http://www.eqclearinghouse.org/2016-04-15-kumamoto/files/2016/04/NZSEE_Kumamoto_Report.pdf



3. Relevant Websites and Links:

Fault line map

- https://gbank.gsj.jp/geonavi/geonavi.php?lat=32.92678&lon=131.08112&z=10&basemap=Google_Terrain&layers=&ol=activeFaults,KumamotoQuake

Geological map

- https://gbank.gsj.jp/geonavi/geonavi.php?lat=32.70895&lon=130.76165&z=13&layers=1044,1172,seamless_geo_detailed

Reports by G-EVER

- <http://g-ever.org/updates/?p=214>

Report by Earthquake Research Institute, University of Tokyo

- http://www.eri.u-tokyo.ac.jp/en/?page_id=183&id=2387

Strong motion records (K-NET/KiK-net)

- http://www.kyoshin.bosai.go.jp/kyoshin/quake/index_en.html

Landslides caused by Kumamoto Earthquake

- <http://blogs.agu.org/landslideblog/>
- <http://blogs.agu.org/landslideblog/2016/04/18/kumamoto-earthquake-1/>

Clearinghouse Website

- <http://www.eqclearinghouse.org/2016-04-15-kumamoto/>



4. Kumamoto Reconnaissance Visit Full Team List

	Name	Title	Affiliation
New Zealand Team			
1	Ken Elwood	Professor	University of Auckland
2	Rajesh Dhakal	Professor	University of Canterbury
3	Mike Stannard	Chief Engineer	Ministry of Business Innovation and Employment
4	Didier Pettinga	Senior Project Engineer	Holmes Consulting Group
5	Mehdi Sarrafzadeh	PhD Student	University of Auckland
6	Helen Ferner	Technical Director - Structural Engineer	Beca
Japan Team			
1	Masaki Maeda	Professor	Tohoku University
2	Yasushi Sanada	Associate Professor	Osaka University
3	Takuya Kioke	Masters Student	Tohoku University
4	Norihiro Hosoya	Masters Student	Tohoku University
5	Linfei Hao	PhD Student	Tohoku University
6	Joji Sakuta	Structural Engineer	Horie Engineering and Architectural Research Institute Co.,Ltd,
7	Tomomi Suzuki	Master student	Osaka University

8	Tomohisa Mukai	Chief Researcher	Building Research Institutel
9	Masanobu Sakasita	Chief Researcher	Building Research Institutel
10	Akihiro Nakamura	Researcher	Building Research Institutel
Taiwan Team			
1	Hwang, Jin Hung	Professor	Geotechnical Division Head of NCREC
2	Chung, Lap-Loi	Professor	Building structure Division Head of NCREC
3	Yao, Chao Chih	Professor	Dept. of Architecture, NCKU
4	Shao, Peichun	Professor	Dept. of Land Management and Development, CJCUC