Seismological, Geological, and Geotechnical Engineering Aspects of the 2018 $M_w$ 6.6 Hokkaido Eastern Iburi Japan Earthquake

Robert Kayen (GEER Team Leader; UC Berkeley & USGS), alphabetically Don Anderson (BYU), Jeff Bachhuber (PG&E), Alex Grant (USGS), Chris Hitchcock (PG&E), Chris Madugo (PG&E), Atsushi Mikami (Tokai U), Matthew Motto (PG&E), Joseph Sun (PG&E), Yi Tyan Tsai (UCLA), Pengfei Wang (UCLA), Brad Wham (CU, Boulder), Paolo Zimmaro (UCLA)

**EERI’s VERT (Virtual EQ Reconnaissance Team)** developed a re-reconnaissance data set from the web for the team

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Geotechnical Extreme Event Reconnaissance: Core Objective of GEER Mission

- Documentation of important case histories that advance geotechnical engineering and geoscience research, policy, and practice.

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2018 Hokkaido Eastern Iburi earthquake

- **M6.6** Iburi Subprefecture in southern Hokkaido, Japan, on 6 September 2018 at 3:08 a.m.

- **Mechanism:** moderately dipping reverse fault. The epicenter was near Tomakomai at a depth of 35.0 kilometers (21.7 mi). The event-rupture is within the upper crust above the subducting slab.

- **Intensity:** maximum intensity of 7 on the Shindo scale.

- **Fatalities:** Forty-one people were confirmed dead (~35 in landslides) and around six hundred and eighty were injured.

- **Name:** ‘Hokkaido Eastern Iburi Earthquake of Heisei 30’
Extremely high ground motions in epicentral area

Oiwake HKD127:
PGA $1.796 \text{ g (3-D)}$
PGV$_{\text{Horiz}}$ 97 cm/s

PGA’s of $\text{M6.6}$ 2018 event at Atsuma/Mukawa were
~twice those of the 2003 $\text{M8.0}$ Tokachi-Oki

(Malhotra, 2018)
High seismic intensities felt throughout the Mukawa, Abira, Atsuma, Ebetsugawa Sapporo lowland sedimentary basins

Shindo scale max. intensity 7

Sapporo

Atsuma
Precipitation at Atsuma in Aug.

Daily rainfall (blue)

Source: Japan Meteorological Agency

Precipitation at Atsuma in Sept.

Typhoon #21 “Jebi”

2018 Hokkaido Earthquake.

Source: Japan Meteorological Agency
CASE HISTORY 1: High density co-seismic landslide activity in Shirasu soil
Atsuma area landslides: Entirely Shirasu debris slides, slope parallel, typically 1-4m of material

Slope heights: 30-50 m
Slope angles: 25°-30°
Runouts: 50m-150m

(UAV Structure-from-Motion [SFM] model from 300m)

CASE HISTORY 1: High density co-seismic landslide activity in Shirasu soil
Recent Shirasu pumice soil and ashfall in the Atsuma region is from Mt Tarumae, south of Shikotsu-Ko: Units date from 1739-to-9 kya.
Alex Grant (USGS) @ Hirono Slide pointing to Kawabata marine mudstone beneath failed Shirasu soil.
Shirasu debris slides effecting Atsuhororo Dam, Yoshino area

CASE HISTORY 1: High density co-seismic landslide activity in Shirasu soil
Debris slides effecting Atsuhooro Dam, Yoshino area

- South and west facing slopes more effected: possibly linked to ground motions or exposure to westerly Mt Tarumae ashfall

- Shirasu soil seen floating on reservoir surface.

- Runouts of 100+ meters exceeding slope height by 2x.

UAV model 500m

CASE HISTORY 1: High density co-seismic landslide activity in Shirasu soil
Kiyota-Ku residential area in Sapporo leveled with 1980’s placed-fill in a 10m ravine of 40 kya pumice
CASE HISTORY 2: Flow failure of placed 40kya Shirasu fill soil, Sapporo
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• Flow failure - Kiyota Ku
• Flow failure - Kiyota Ku

Orange Zone: Upslope settlement area above liquefied ground

Blue Zone: Downslope ejecta that flowed laterally out of the ground and buried portions of the lower neighborhood

CASE HISTORY 2: Flow failure of placed 40kya Shirasu fill soil, Sapporo
• Flow failure evacuated soil in the topographically high portion of Kiyota- Ku, collapsing the pavement.
• The storm-drain manhole extends 10m to base of ravine fill and did not settle.

CASE HISTORY 2: Flow failure of placed 40kya Shirasu fill soil, Sapporo
CASE HISTORY 2: Flow failure of placed 40kya Shirasu fill soil, Sapporo
Two translational landslides occurred within Kawabata marine mudstone bedrock with well-defined headscarps, sidescarps, and translated blocks.

900 m long, 200-300 m wide, slid 350 m south-southwest, blocked a 200 m-wide stream valley.

UAV image showing Horonai megaslide with offset of electrical tower relative to original electrical alignment: 42.736835°, 142.005206°.
UAV image of the upper graben within the headscarp of the Hobetsuizumi megaslide. Note collapsed electrical tower (within red circle). 42.719687°, 142.151401°

Hobetsuizumi translational landslide also occurred within Kawabata marine mudstone with well-defined headscarps, sidescarps, and translated blocks. Note collapsed electrical tower.
Exposure of the Kawabata formation within a deep-seated translational rock slide (image Jeff Bachhuber, PG&E)

Kawabata marine mudstone Exposure:
Weak zones may be ash layers or marine clay.

CASE HISTORY 3: Deep-Seated Landslides - Hobetsuizumi megaslide
Other Infrastructure Damage:

- The earthquake cut power to all households in Hokkaido (Isolated power network, Hokkaido Electric Power).

- Coal-fired power plant in Tomakomai was damaged by fires. By 6:30 p.m. 9/6, power was restored to 340,000 households in Hokkaido (10%). By 9/8 ~85% restored power.
Other Infrastructure Damage:

- Gravity, rockfill, and embankment dams performed well (a PG&E primary focus of reconnaissance).
- Residential/commercial structures performed well.
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