EVENT BRIEFING

		Event:	Typhoon Hagibis and Oct. 12, 2019 Earthquake
		Region:	East Asia
Authors:	Selim Günay, Pacific Earthquake Engineering Research Center, University of California, Berkeley David O. Prevatt, Engineering School of Sustainable Infrastructure & Environment Ian N. Robertson, University of Hawaii at Manoa Khalid M. Mosalam, Pacific Earthquake Engineering Research Center, University of California, Berkeley		
Editors:	Tracy Kijewski-Correa, University of Notre Dame David Roueche, Auburn University		
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Key Lessons

- The occurrence of an earthquake during landfall of Typhoon Hagibis is a rare opportunity to observe the impact of simultaneous multi-hazards on structures.
- Current US building codes do not include load combinations of wind and earthquake forces occurring simultaneously; however, this event might warrant revisiting the current load combinations to consider combining a design level wind event with a lesser earthquake or vice versa.
- These simultaneous events also highlight the importance of instrumentation in buildings to capture valuable data that can be used for identifying structural characteristics, understanding the structural response, and updating analytical models.
- The combination of extreme rainfall-induced runoff, along with storm surge and wave action at river estuaries warrants consideration in modeling of effects of major tropical cyclones.
- The number of households without power were 34,000 as of the morning of 10/16/2019, down from a peak of 520,000, indicating a fast response time and quick recovery for an event of this size. These and other indicators of community resilience are critical to improve future performance. A coordinated effort from the extreme events community is needed to develop tools and methods for systematic documentation and quantification measures related to resilience and recovery time.

Introduction

On the evening of October 12, 2019, the southern coast of Japan experienced the consequences of Typhoon Hagibis and a Mw 5.3 earthquake, almost simultaneously. Typhoon Hagibis made landfall on the Izu Peninsula of southeastern Honshu just after 6 pm local time on 12 October. Upon crossing the coast, the system had 10-minute sustained winds of 150 km/h (90 mph) and one-minute sustained winds of 155 km/h (100 mph), equivalent to a Category 2 hurricane (NII, 2019).

Around 20 minutes later, at approximately 6:22 pm local time, a magnitude 5.3 earthquake, with a depth of 59.5 km, struck 55 km south east of Katsuura, the nearest city to the epicenter on land (USGS, 2019). Although this earthquake had only moderate intensity, simultaneous occurrence of wind storms and earthquakes in the same local (Fig. 1) is a unique occurrence and opportunity to explore structural performance under simultaneous multi-hazards.

Current US building codes do not have any load combinations that consider wind and earthquake forces occurring simultaneously, primarily because of the low probability that both would be design-level events. However, this current event poses whether current load combinations should consider a combination of a design-level wind event with a moderate earthquake or vice versa.

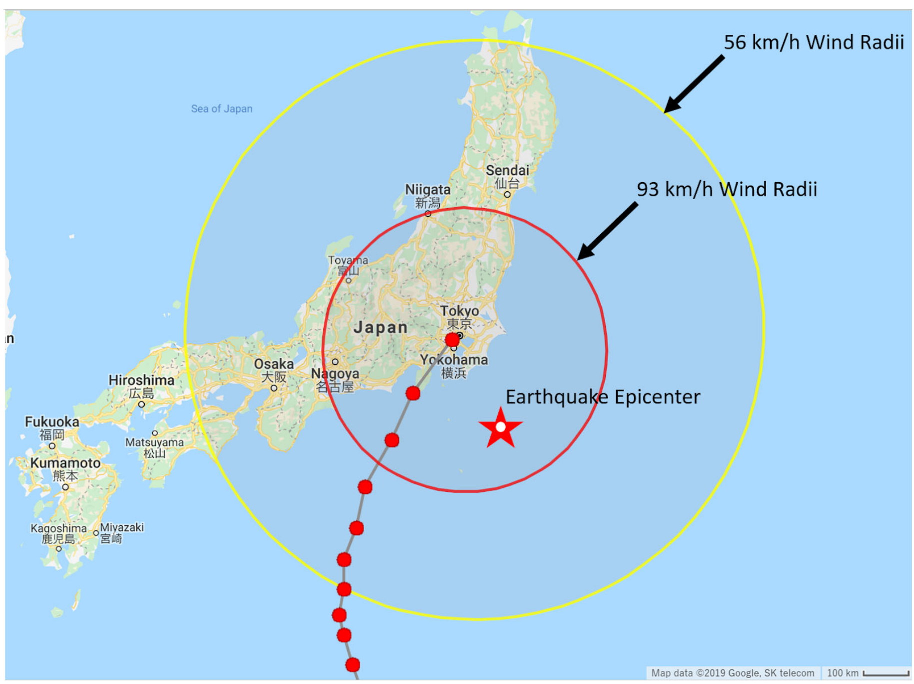

Figure 1. Visualization of typhoon track relative to earthquake epicenter (star). Red (inner) circle shows radius of Typhoon (Class 5) winds and green/yellow (outer) circle shows radius of Tropical Storm (Class 3) winds. (Source: Digital Typhoon, 2019).

Typhoon Characteristics

On Saturday 12 October, 2019, Typhoon Hagibis made landfall on Japan’s main island, Honshu, bringing torrential rains, Category 2 strength winds and storm surge flooding (Fig. 2). Hagibis had previously been a super typhoon – having estimated maximum wind of at least 150 mph. Highest sustained winds were measured at 78 mph at Haneda in the Tokyo Prefecture. In the earlier life of the storm track on 6 October, 2019, Hagibis intensified rapidly in just 24 hours from tropical storm strength (60 mph) to 160 mph (Category 5). This was the 19th named storm for 2019 in the Western Pacific tropical cyclone zone.

To date, there are at least 77 fatalities attributed to Hagibis, with 10 still missing and many more injured (NHK, 2019). 40,000 homes were still without electricity on Monday (10/15/2019) afternoon, local time (Evening Standard, 2019). Much of the transportation system in Tokyo was affected by the storm and associated flooding. The typhoon also led to other widespread transport disruptions over the weekend, with flights, bullet trains and other transport canceled across Honshu, Japan's main island (CNN, 2019a). On Tuesday (10/16/2019), Prime Minister Abe said at a session of the Upper House Budget Committee that his government was planning to designate Hagibis a “severe natural disaster.” This makes municipalities in affected regions eligible for increased state subsidies for reconstruction work.

In addition to hurricane force winds, Hagibis brought storm surge and waves to the South and East shores of Honshu Island. Because Japan has a history of typhoons and tsunamis, many shorelines and river estuaries are protected by breakwaters and concrete walls or earthen levees. These appear to have been effective at limiting damage to coastal ports and harbor facilities (Fig. 3); however, the storm also brought extremely high rainfall (Fig. 4). The combination of elevated sea level and wave runup, plus extreme riverine flow due to the heavy rainfall may have contributed to some river channels being overtopped. Extensive flood damage resulted in a number of river valleys, impacting homes (Figs. 5 and 6). According to the Fire and Disaster Management Agency of Japan, 9,962 houses had been flooded across the country (CNN, 2019a). The heavy rain also caused 146 landslides across the country.

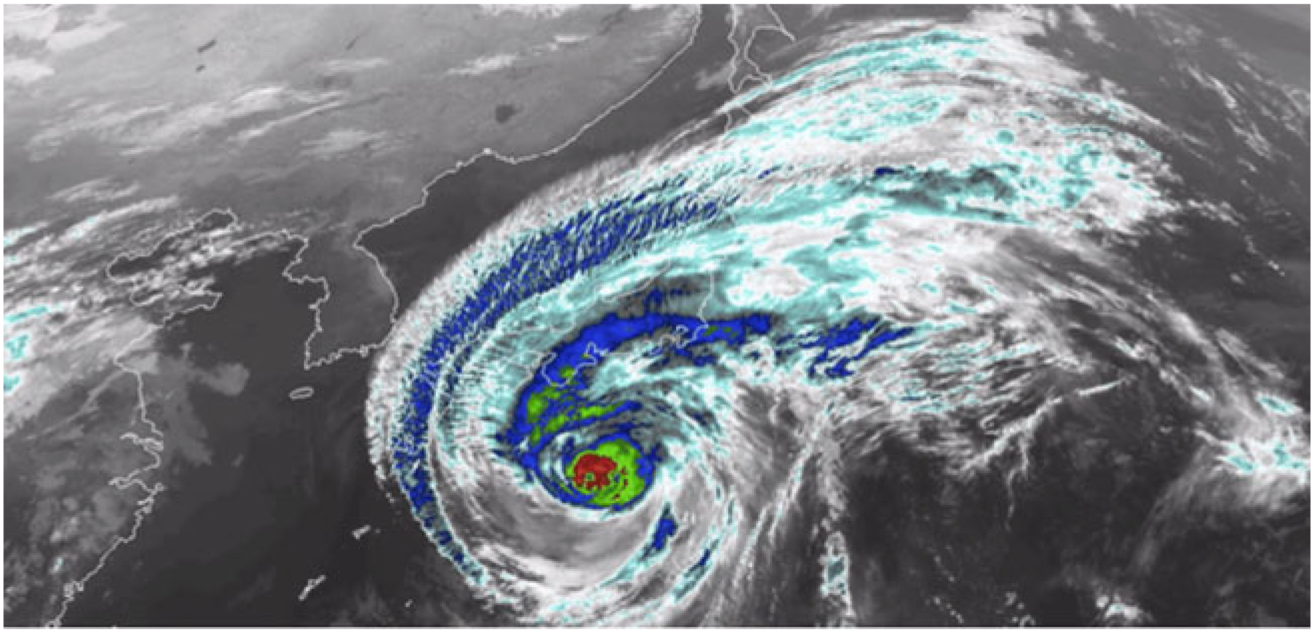

Figure 2: Typhoon Hagibis as it approached Japan from the South (Source: AccuWeather, 2019).

Figure 3: Wave striking breakwater in Kiho, Japan (Source: Toru Hanai/Associated Press; New York Times, 2019).

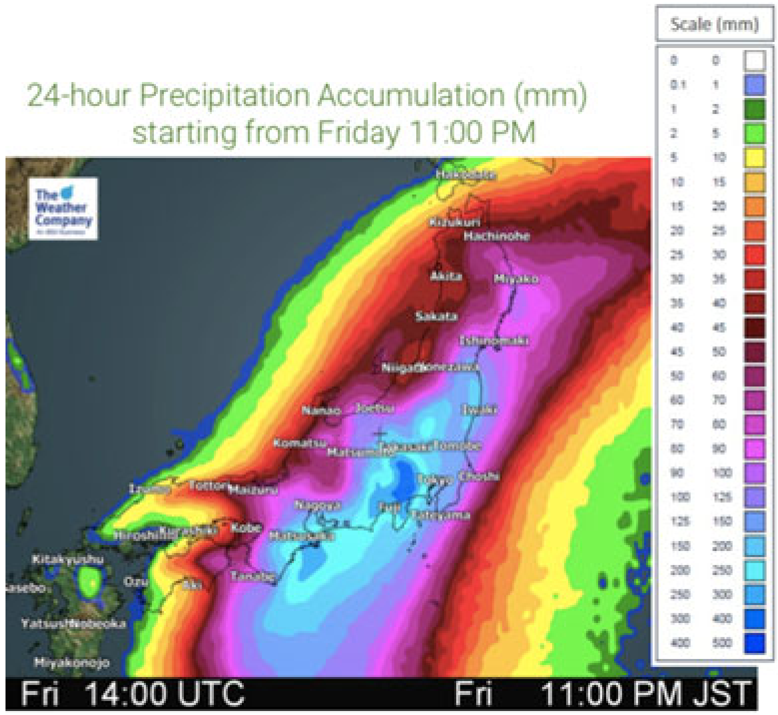

Figure 4: 24-hour rainfall accumulation starting from 11:00 pm Friday, Oct. 11, 2019, local time (Source: Weatherwatch, 2019).

Figure 5: Flooding due to levee failure along the Chikuma River in Nagano, Central Japan (left, Source: Aljazeera, 2019), areas flooded by the Abukuma River following Typhoon Hagibis in Tamagawa town, Fukushima prefecture (right, Source: The Atlantic, 2019).

 

Figure 6: Floodwater flow through a break in the riverbank of the Akiyama River in Sano, Tochigi (left, The Atlantic, 2019), flood-damaged homes in Nagano (right, CNN, 2019a).

Earthquake Characteristics

On Oct. 12, 2019, at approximately 6:22 pm local time, a magnitude 5.3 earthquake, with a depth of 59.5 km, struck 55 km south east of Katsuura, the nearest city to the epicenter on land (USGS, 2019). Epicenter of the earthquake (Fig. 7) was located in the Pacific Ocean, with coordinates of (34.686°N, 140.569°E). The exact faulting mechanism is unclear; however, based on the epicenter location, it is possible that this earthquake occurred in the boundary between the Philippines and Eurasia plates (Panayotopoulos et al., 2019).

At the time of writing this briefing, the level of shaking is not available from accelerometer data or the USGS ShakeMap; however, considering the magnitude of the earthquake and the nearest distance to city centers (Mw 5.3 and 55 km), the level of shaking is expected to be smaller than 0.05g according to current GMPEs (Ground Motion Prediction Equations). The USGS “Did you feel it?” responses indicate that the earthquake was felt in Yokohama, Tokyo and the surrounding area (Fig. 6). Buildings in Tokyo were also reported to shake and rattle during the earthquake (CBS News, 2019). Taller buildings experienced simultaneous shaking due to the combined wind and earthquake effects. This type of shaking highlights the importance of instrumentation in buildings to capture valuable data that can be used for identifying structural characteristics, understanding the structural response, and updating analytical models.

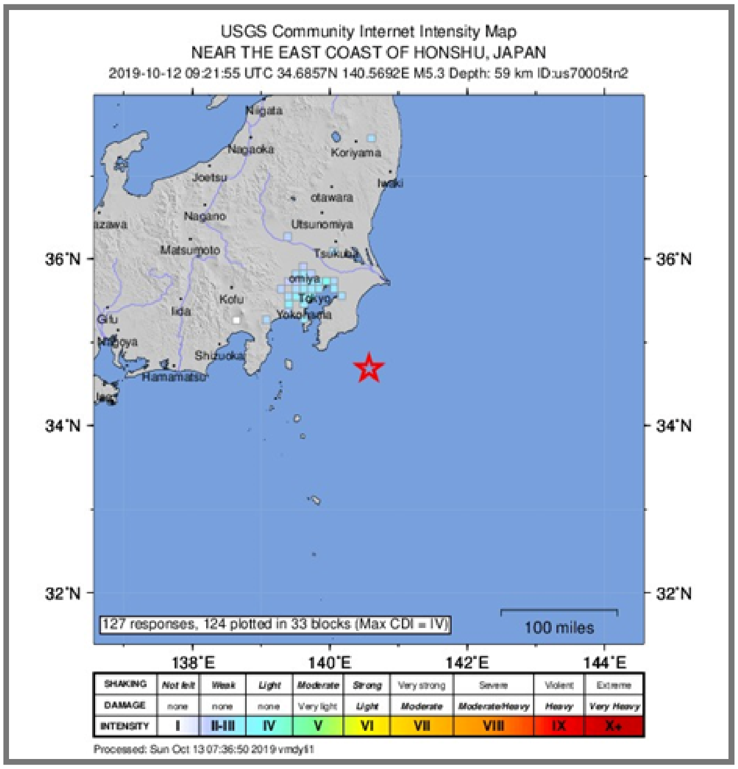

Figure 7: Epicenter location and "Did you feel it?" responses for M_w 5.3 earthquake SE of Honshu Island, Japan (Source: USGS, 2019).

Damage to Structures

Typhoon Hagibis is considered to be the most devastating typhoon to hit the Kanto region of Japan since typhoon Ida in 1958 (Wikipedia, 2019). Considerable damage to residential construction resulted from the high winds, while flooding caused by combined heavy rainfall and coastal storm surge resulted in extensive flooding damage.

Buildings

There was significant wind damage to structures, both to the nonstructural components, such as façades and glazing, and to the structural components, including complete collapse (Figs. 8 and 9).

Infrastructure

Infrastructure damage due to the typhoon included trains and railway structures (Fig. 10) as well as power distribution systems, resulting in more than 270,000 households losing power. Levee failures (Fig. 5) were also reported.

Figure 8: Buildings with damaged façade (Source: Forbes, 2019; CBS News, 2019).

Figure 9: Significantly damaged/collapsed buildings; image on the right may have been due to a tornado spawned by the typhoon (Source: CNN, 2019b; ABS-CBN, 2019).

Figure 10: Damage to a railway bridge and high-speed trains (Source: Forbes, 2019).

Impacts to Community Resilience

Typhoon Hagibis is one of the costliest natural disasters to have hit Japan, with insured losses of more than $9 billion (CNN, 2019a). Some industries have been hit particularly hard, including farming, transportation, and power. As in the case of other storms, the consequences are expected to continue to unfold over time. An estimated 5,500 people remain housed in shelters, according to Japan's Cabinet Office (CNN, 2019a). More than 230,000 people had been evacuated before the storm, demonstrating the importance of disaster preparedness. The number of households without power was 34,000 as of the morning of Tuesday Oct. 16, 2019, down from a peak of 520,000, according to the Japan Industry Minister. This suggests a fast response time and quick recovery for an event of this size. The Industry Minister indicated that areas severely flooded could remain without electricity for more than a week. More than 133,000 households were also without water, according to the Cabinet Office. These numbers are particularly important for quantifying resilience and recovery time and for making appropriate decisions to reduce such disruptions in future events. Therefore, a coordinated effort form the extreme events community is needed to develop tools and methods for systematic documentation and quantification of measures related to resilience and recovery time.

StEER Response Strategy

At present, StEER has not deemed it necessary to form a Virtual Assessment Structural Team (VAST) or Field Assessment Structural Team (FAST) in response to this event. Rather, StEER's present response takes the form of this Event Briefing, which shares with the community StEER's impressions of the event and implications for natural hazard research and practice. Information provided herein was gathered from various websites, including USGS. Therefore, this briefing does not include insights from detailed field investigations. StEER will continue to monitor this event and should the damage to structures warrant the formation of a VAST or FAST, StEER will notify the community through its standard channels.

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