Kuril Islands Earthquake of October 4, 1994

Contributed by Harry Yeh (Department of Civil Engineering, University of Washington). *A preliminary report on the earthquake was reported in the November issue of the Newsletter. The effects of the earthquake were also felt in Japan, as reported in the December Newsletter, where it was referred to as the "Hokkaido Toho-oki" earthquake.* *The publication and distribution of this report was funded by National Science Foundation Grant #BCS-9215158.*

On October 4, 1994, at 1:23 p.m. GMT (0:23 a.m. Oct. 5, local time) an earthquake of magnitude Ms 8.1 struck the southern region of the Kuril Islands. On Shikotan Island, one of the Kuril Islands, the earthquake intensity was reported to be between 9 and 10 on the 12 full scale. Tsunami warnings were issued in the Hokkaido and Tohoku regions in Japan, and in the coastal regions of Hawaii, Oregon, and Washington. All the information received within a few days of the event indicated potentially devastating earthquake and tsunami damage on Shikotan, Kunashir, Iturup, and Habomai Islands. Russian geophysicists immediately planned to organize a reconnaissance team, calling for international collaboration, especially with U.S. and Japanese tsunami specialists. The government of Japan prohibited Japanese participation in the survey because of a continuing territorial dispute between Russia and Japan over the Southern Kuril Islands. Two U.S. researchers joined fifteen Russian scientists to form the international reconnaissance team. The survey was conducted from October 16-30, 1994.

Considering the magnitude and intensity of the earthquake, the number of reported deaths and injuries was low: on Shikotan Island, the closest island to the earthquake source, three people died as a result of the earthquake. This is attributed to the time of the event (middle of the night), and the facts that the electricity was immediately shut down, and the climate was mild so that heating systems were not in use. There were no fires reported during or after the earthquake.

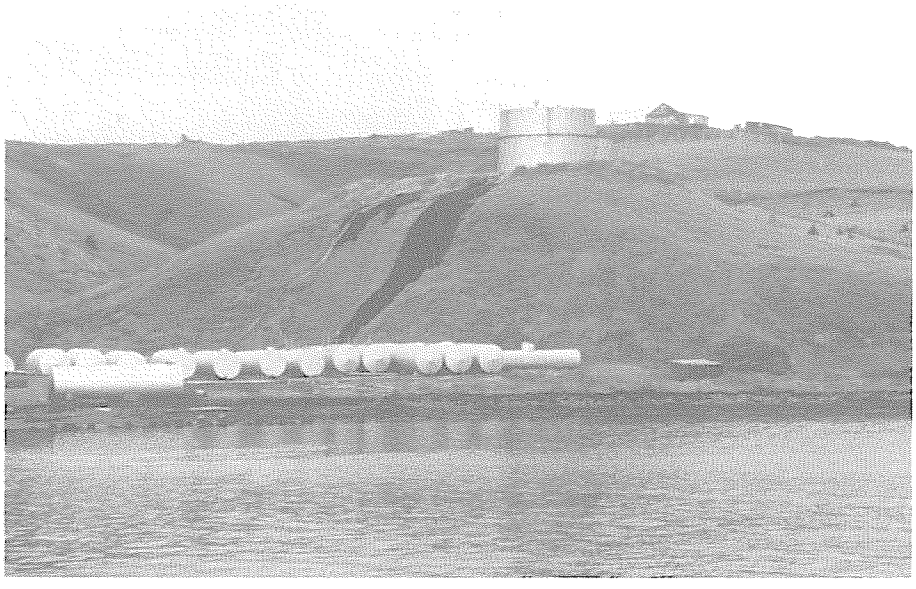

Figure 1—*Oil leak damage from storage tanks in Malokurilsk.*

Oil storage tanks in the villages of Malokurilsk and Krabozavodsk suffered major damage: oil leaked from nearly every tank situated on the hills overlooking the villages. Both ports were heavily contaminated (Figure 1), and as of October 25, there were no signs of a clean-up operation. The tank damage was most likely caused by failure of the foundation; all the tanks were placed on hillside cut-and-fill terraces.

The elementary school house in Krabozavodsk was heavily damaged. The building tilted approximately 15 degrees from the horizontal and the classroom floors were completely destroyed. The school was located near the top of the hillside and failure of the foundation was a likely cause of the damage. Apartments located adjacent to the school house showed no external signs of damage.

As seen many times before, brick and masonry structures with inadequate or no reinforcement did not perform well in the earthquake; light wooden structures, however, did. Although the interiors were heavily damaged and brick chimneys were destroyed, many wooden apartments and houses were still standing after the earthquake.

Many large landslides and fissure formations were observed on Shikotan. Near Malokurilsk, major fissure formations were observed on a grass-covered hill (Figure 2). It appears that a massive landslide

occurred into the sea, causing the formation of this fissure approximately 200 m from the sea cliff. Other significant fissure formations were found in Krabozavodsk, and were also located at a hill top leading to the sea cliff. Another landslide in Malokurilsk carried the radio station used for vessel navigation into the sea.

In spite of the many significant landslides observed along the Shikotan coast, the local tsunami runup was not abnormally high. This indicates that landslides were limited to those occurring above sea level; no major underwater slumping resulted from the earthquake. There is clear evidence, however, in the tide-gage record of Malokurilsk Bay that the island of Shikotan subsided by at least 60 cm. Considering the many major fissure formations, the island is expected to have distorted horizontally as well.

Measured tsunami runup heights along the southern coast (directly facing the source of the earthquake) of Shikotan were approximately 5-7 m from the mean sea level, while along the northern coast (shadow zone: backside of the island from the tsunami source) they measured approximately 3 m. The maximum runup value recorded in Shikotan was 16.6 m, however, this value is associated with a local wave splash in a small area, approximately 10 m wide on a steep hill. The observed runup values are fairly uniform along each coast, which leads to the conjecture that the tsunamis which attacked the island were of long-period waves, i.e. producing a gradual increase and decrease of the sea surface. This is supported by the observation of no significant scarp formation on the beach surface: significant erosion and vegetation washout by the flows were not found. It should be noted that the measurements along the northern coast were limited to locations near the heads of bays; clear tsunami traces were not evident in all locations, and other sites were not readily accessible because of steep, rocky cliffs. Hence, the small runup values could have resulted from measurements being taken at well protected areas in the shadow zone of the island.

Figure 2—Major fissure formation near Malokurilsk, Shikotan. The fissure, maximum 30 m wide, 15 m deep, and approximately 350 m long, is formed parallel to the major landslide (approximately 80 m high) along a sea cliff. Note that the size of trees shown is approximately 5 m high.

Many vessels were reportedly damaged or destroyed by tsunamis at Yuzhno-Kurilsk on Kunashir Island. Tsunami runup heights along the southern coast of Kunashir Island were between 2.5 and 6.5 m, with a maximum local value of 9.8 m. There is a high runup region north of Yuzhno-Kurilsk, perhaps caused by the refraction of tsunamis which propagated around Shikotan Island. Detailed analyses of tsunami runup along Kunashir Island will be important for understanding the effects of an island chain (Habomai and Shikotan Islands) on tsunami penetration to the land behind it (Kunashir Island). Similar configurations can be found elsewhere, for example, the Santa Barbara Island chain and the Los Angeles area.

Presently, there are three seismic recording stations in the region, one each on Shikotan, Kunashir, and Iturup Islands. Because of the recent economic hardship experienced by the scientific and academic communities in Russia, especially in the Far East Region, none of these seismic stations has modern seismographic equipment. It has also been difficult to retain experienced operators on the islands. There is no doubt that the Kuril Islands are located in a geophysically very important region. Another earthquake might generate much stronger tsunamis affecting not only the Kuril Islands and Japan, but also Hawaii and the West Coast of North America. Proper and accurate seismic and tsunami measurements on the Kuril Islands are essential and urgently needed by the entire Pan Pacific community.