

PROTECTING AGAINST ROCKFALL

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The State of Hawaii Department of Transportation (HDOT) is committed to protecting the public against rockfalls along our roadways. This is a challenging task involving uncertainties about when and where rockfalls may occur, high costs of mitigation, as well as cultural, historical and environmental concerns. It is imperative that we, as engineers, seek appropriate solutions to these kinds of recurring problems.

Waimea Bay on the north shore of Oahu is a case in point.

On March 6, 2000, approximately twenty cubic yards of rock dislodged from the top of a 90-foot high vertical cliff along the north side of the bay and fell onto Kamehameha Highway directly below. As additional hazardous potential rockfalls still existed, HDOT initiated a major mitigation project at the site. The highway was closed for a total of 95 days with traffic rerouted through a temporary bypass built on the adjacent beach.

The mitigation relocated the roadway away from the cliff to allow for the construction of a 10-foot wide and 5-foot deep rockfall catchment ditch and the installation of a 1,000-foot long and 10-foot high fence with a jersey barrier along its base. The setback of the roadway away from the cliff employed a mechanically stabilized earth wall comprised of intervening layers of surge rock and polyethylene geogrids.

In February of 2007, a large boulder was dislodged from an area just below the source of the previous rockfall. The safety features in place contained the boulder within the catchment ditch.

On April 7, 2007, a large rock mass of about 500 cubic yards from the two earlier sources slid off the cliff face. The catchment ditch worked beyond its design capacity and contained most of the debris. Portions of the rockfall fence were crushed to the ground but it effectively reduced the amount of debris that ended up on the roadway. No one was injured and the only vehicle accident occurred when a truck attempted to negotiate through the debris after police had already closed the road to traffic.

Immediately following the April rockfall, HDOT geotechnical engineers and Earth Tech engineers and geologists assessed the stability of the slope; Goodfellow Brothers mobilized heavy equipments to break up large boulders; Janod Construction checked the cliff face for possible native Hawaiian burial sites and scaled the mountainside to remove unstable rocks; and Tajiri Lumber and HDOT maintenance crews hauled away the debris under the supervision of archeologists monitoring for possible burial remains.

HDOT managed to open the highway, the only link around the north side of the island, for rush hour traffic on April 9, only two days after what is considered to be Hawaii's largest rockslide event along a highway in recent memory. HDOT's rapid and efficient response

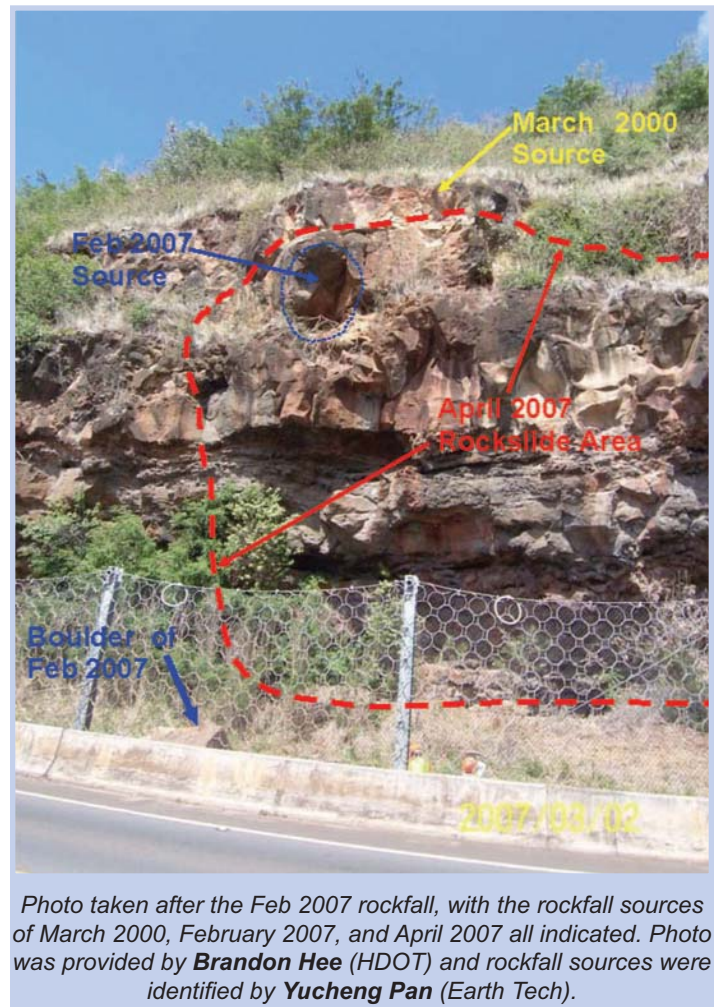


Photo taken after the Feb 2007 rockfall, with the rockfall sources of March 2000, February 2007, and April 2007 all indicated. Photo was provided by **Brandon Hee** (HDOT) and rockfall sources were identified by **Yucheng Pan** (Earth Tech).

ROCKFALLS ALONG HAWAII HIGHWAYS

set a high standard for the nation and a new record in Hawaii. Many highway users expressed their gratitude and satisfaction to the crews working at the site.

HDOT's mission to adequately protect highway users against rockfalls requires reasonable engineering judgment, and, oftentimes, compromise. For example, in order to achieve proper catchment, the highway should ideally be relocated even farther away from the cliffside. This relocation was not possible because it would disrupt the world famous Waimea Bay beach and the existing protected marshlands. Draping a strong ringnet system over the entire slope would also be effective but it would adversely affect significant archeological, cultural, and aesthetic conditions. Therefore, in the spirit of context sensitive design, and based on engineering judgment, the original impact fence was designed only to retain medium-sized boulders falling from the cliff, rather than to contain large mass rockslides.

We believe this was the correct and appropriate solution. Based on the recent rockfall events, however, we are looking into possibly strengthening the fence to handle larger impact energies. We are also considering the use of bolting, demolition, and localized netting for other specific rockfall hazards in the area identified through additional surveys.

HDOT strives to be proactive in rockfall protection and hazard mitigation. Based on the Oahu island-wide rockfall hazard rating completed by HDOT and Earth Tech, funding has been allocated to address the hazardous slopes of Makapuu point (northern half) and Pali Highway near the Kapaa Quarry Road, within the next couple of years. The rockfall site on Kamehameha Highway on the south cliff side of Waimea Bay is rated high and the design and environmental assessment portion of the work is scheduled to begin this year.

We are also finalizing a rockfall hazard rating study to help us prioritize projects around the State. Recent rockfall projects in response to heavy rains in early 2006 and the effects of a magnitude 6.7 earthquake in October of the same year will be accounted for in this study.

Continuous monitoring of sites identified as being prone to rockfalls is also critical. HDOT and University

of Hawaii geology and mapping faculty and researchers are considering the use of new scanning technology to evaluate slopes based on topography, slope, and curvature plots.



Condition after April 2007 rockslide showing crushed rockfall fence.

There are all kinds of hazards that surround us as we go about our daily lives. As engineering professionals here at HDOT, it is our duty to do our best in providing safe passage for all of Hawaii's travelers. We will continue to use sound practice in developing and maintaining our highway facilities, and also be proactive and open to new technologies and processes in order to do our jobs better. Rockfall hazard mitigation is one of the many areas in which HDOT looks to stay ahead of the curve because too many people are counting on us to do so.

Ardalan Nikou and Yucheng Pan of Earth Tech were major contributors to this article.