DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Geotechnical / Structures

OCTOBER 2017

Project Title:
Evaluation of LIDAR as an Emerging Geotechnical Data Collection Tool

Task Number: 1648

Completion Date: December 12, 2014

Task Manager:
Arvern Lofton, P.E.
Transportation Engineer, Electrical
arvern.lofton@dot.ca.gov

Application of Three-Dimensional Laser Scanning for the Identification, Evaluation, and Management of Unstable Highway Slopes

Investigating the Use of Ground-Based Light Detecting and Ranging (LiDAR) Technology for Highway Geotechnical Applications.

WHAT WAS THE NEED?

California contains a variety of terrains including unstable, steep sloped terrains that the California Department of Transportation's (Caltrans') Geotechnical & Structures program manages. Identifying, evaluating, and categorizing comparatively high-risk slopes remain labor intensive tasks further complicated by a broad range of geologic conditions that pose safety risks such as rockfalls and landslides.

In the past several years, Light Detecting and Ranging (LiDAR) gained acceptance as a potentially valuable technology for characterizing rock mass. In addition, deployment of this technology in geotechnical applications potentially offers significant improvement in design and construction practices through monitoring slopes and cuts during construction, developing higher quality rock face maps for design, and enhancing characterization of rock joints and other geologic features. However, in order to successfully implement the LiDAR technology into geotechnical operations, Caltrans needs issues associated with LiDAR addressed such as a lack of documented, qualified procedures for data acquisition to ensure accuracy of LiDAR data, and the ability to analyze and process the vast sizes of LiDAR produced 3D point clouds with traditional software products.

WHAT WAS THE GOAL?

The goal of the research is to demonstrate geotechnical applications of ground-based LiDAR for highway slopes and provide training on the use of point cloud processing software.

Caltrans

DRISI provides solutions and knowledge that improves California's transportation system

WHAT DID WE DO?

Caltrans partnered with the Arizona Department of Transportation (ADOT) and six other DOTs in a collaborative research study with the University of Arizona (UA) to incorporate 3D laser scanning technology into highway geotechnical applications. UA conducted ground-based LiDAR scans and analyzed the resulting point clouds for each of the participating DOT partners.

Specifically for California, UA performed several scans and analyzed the results of a rock slope site along State Route (SR) 299. Next, UA conducted point cloud processing for rock mass characterization, roughness and persistence, and slope stability analysis.

The UA researchers developed best practices for field LiDAR scanning and efficient repeatable ways to process LiDAR data for highway geotechnical applications. In addition, the UA research team trained Caltrans geotechnical staff and other DOT personnel on LiDAR scanning and point cloud processing as well as provided a copy of the Split-FX point cloud processing software.

WHAT WAS THE OUTCOME?

Caltrans learned that implementing ground-based LiDAR provides lots of useful information to assist with highway geotechnical applications. Also, Caltrans gained awareness of some limitations associated with the ground-based LiDAR technology for geotechnical applications such as LiDAR scanning's inability to obtain information on rock core throughout the desired rock mass, intact rock strength, and groundwater hydrology or rainfall.

The research addressed Caltrans needs as far as providing best practices for LiDAR field scanning and for point cloud processing, which includes details on optimal ways of how to scan and process.

The results from the research lead to some recommendations.
1. Follow-up research at some of the pooled fund sites to conduct additional LiDAR scanning for change detection and integrating airborne LiDAR data
2. Using the pooled fund sites as benchmark research to compare other new technologies and traditional practices of site characterization and monitoring
3. Future research on incorporating mobile LiDAR technology to potentially enhance safety and efficiency of practices for geotechnical analysis of highway slopes, including rock mass characterization, rockfall, slope stability, and change detection.

WHAT IS THE BENEFIT?

Caltrans, ADOT, and seven other DOTs benefited from documented best practices pertaining to LiDAR field scanning and point cloud data processing. The best practices included approximate times to complete field scans of site areas based on the square footage of the site and the type of stationary scanner used throughout the research. In addition to LiDAR field scanning, Caltrans and eight other DOTs gained insight on estimated lengths of time to process the point cloud data resulting from the LiDAR field scans. Ultimately, Caltrans and other DOTs benefited from obtaining more accurate and precise information in a safer manner with ground-based LiDAR scanning technology compared to traditional practices of gathering geotechnical information on unstable highway slopes.

LEARN MORE

View the Final Report
https://dot.ca.gov/-/media/dot-media/programs/research-innovation-system-information/documents/final-reports/ca15-1648-finalreport-a11y.pdf

IMAGES

Image 1: Westbound View of the California SR 299 Highway Cut.

Image 2: Difficult Scanning from across a Narrow Highway at the California Site.

Scan	Number of Points	Scan Time (approximate)	Average Slope Information			
			Length (m)	Height (m)	Dip	Dip Direction
NFCurve1	1,409,814	17 minutes	21.6	13.5	21.8	113.6
NFCurve2	1,707,888	18 minutes	36.8	19.3	65.3	113.8
NFCurve3	1,475,370	17 minutes	30.3	18.8	78.1	120.2
NFCurve4	1,521,520	18 minutes	23.4	14.1	60.8	136.1
NFCurve5	1,370,616	17 minutes	38.2	15.5	74.8	124.3
NFCurve6	1,690,430	19 minutes	65.4	19.8	76.7	128.6
NFCurve7	944,958	15 minutes	87.3	18.3	73.9	126.0
Total	10,120,596	2 hours				

Image 3: Scan Information for the California Site

Image 4: Approximate Locations of Scans NFCurve1 to NFCurve7.

Image 5: Color Point Cloud of the NFCurve7 LiDAR Scan.