

Puerto Rico Geotechnical Asset Management Efforts

51st Southeastern Geotechnical Engineering Conference

Ricardo J. Romero-Ramírez, PhD CE, PhD GE, PE María Elena Arroyo-Caraballo, MSCE, PE







- Puerto Rico Highways and Transportation Authority (PRHTA) organization overview
- PRHTA GAM efforts
 - Previous inventorying initiatives
 - What are geotechnical assets?
 - Why implement a GAMP?
 - Geotechnical assets taxonomy
 - Geotechnical assets inventory and condition assessment
 - Geotechnical report and boring log databases
- Challenges
- Next steps



What is PRHTA?

- PRHTA = Puerto Rico Highways and Transportation Authority "Autoridad de Carreteras y Transportación" (ACT)
 - Public corporation created by Act 74 of June 23, 1965, under the Puerto Rico Department of Transportation and Public Works (DTOP).
 - PRHTA is responsible for developing, operating, and maintaining Puerto Rico's toll roads, highways, bridges, tunnels, and other mass transit facilities.
- DTOP = "Departamento de Transportación y Obras Públicas", Department of Transportation and Public Works (DTPW)



PRHTA Federal Funding

- The current Administration has developed a plan to obligate \$135 million annually from the Federal Highway Administration (FHWA) and \$20 million from the Federal Transit Administration (FTA).
- The goal of the PRHTA is to comply with four key objectives including:



PRHTA proposed organization structure



HIGHWAYS & TRANSPORTATION



the Financial Oversight and Management Board for Puerto Rico (February 22, 2022)





Soils Engineering Office (SEO)

- SEO was created in 1975 with both Soils Engineering and Engineering Geology divisions
- Since 1995, the SEO does not own soil investigation or soil characterization equipment
- The SEO is in a process of reorganization
 - Geotechnical Engineering Office (GEO)
 - Hire a Geological Engineer and a Geotechnical Engineer
 - First Draft of the Standard Operating Procedure (SOP) April 2022
 - Requested FHWA Review of Geotechnical Practice
 - Submit a proposal to the Executive Director of the PRHTA

SEO Current Roles







GEO Proposed Roles











SEO Resources

- The SEO is composed of the following personnel:
 - 4 Geotechnical Engineers
 - 2 Engineering Technicians
 - 1 Driver
 - 1 Executive Assistant
 - 1 Geotechnical Engineering Consultant
 - 1 ArcGIS Consultant



PRHTA GAM Efforts



Previous data management efforts

- Geotechnical report library (1960's)
- Index cards
- MS Access
- Interest in the creation of a georeferenced (GIS) report and borehole inventory (2004)
- FHWA funding since FY2014-15 under the State Planning and Research Program (SP&R)
 - Funding is for the PR National Highway System (NHS)

Development of data management







National Highway System of Puerto Rico



HIGHWAYS & TRANSPORTATION



Puerto Rico Road Network









PRHTA's TAMP and Resiliency

- The PRHTA TAMP only addresses pavements and bridges of the roads composing the NHS system.
- The PRHTA must submit to the FHWA an updated TAMP on or before December 27, 2022. Resiliency will be included in the upcoming TAMP revision.
- The PRHTA TAMP committee is considering implementing a GAM in an internal version of the TAMP. Once the PRHTA GAM is polished, they will consider including it in the official TAMP.



What are geotechnical assets?

- Geotechnical Engineering Concerned with the engineering behavior of earth materials. It uses the principles of soil mechanics and rock mechanics for the solution of its respective engineering problems.
- Geotechnical assets retaining walls, unstable slopes, rockfall sites, cut slopes, embankments, and tunnels



From Geotechnical Asset Management Implementation Concepts and Strategies Publication No. FHWA-CFL/TD-13-003



Why implement a GAM?

- Enables an agency to measure and manage the life-cycle investment of geotechnical assets based on performance, cost-effectiveness, and risk tolerance.
- Reduces the life-cycle cost of unplanned repairs and reconstruction.
- Without GAM an agency simply embraces uncertainty, accepts unknown magnitudes of risk, and makes uninformed life-cycle investment decisions.



Modified from NCHRP Research Report 903: Geotechnical Asset Management for Transportation Agencies, Volume 2: Implementation Manual





PRHTA GAM Inventories





PRHTA Geotechnical Assets Inventories

- Task 1 Small Bridges, culverts, and retaining walls
- Task 2 Development of a Geotechnical Report and Boring Log Database
- Task 3 Development of an Unstable Slope Management Program





Task 1 - Small Bridges, Culverts, and Retaining Structures

- Defined assets to be collected and developed an in-house collection guide
- "Small bridges" are those whose length is ≤ 20 feet. ("Non-NBI bridges")
- "Culverts" vary in size and shape but do NOT qualify as bridges (NBI), as "small bridges" (non-NBI bridges), or as storm drains.
- "Retaining structures" are all earth retaining structures made of concrete, steel, or modified soil.





Culvert Inventory and Condition Assessment

- Started with a custom inventory using ArcGIS Collector
- Migrated the inventory to ArcGIS Survey 123, and modified the template to incorporate the recommendations of the "Culvert Assessment and Decision-Making Procedures Manual for Federal Lands"

CULVERT ASSESSMENT AND DECISION-MAKING PROCEDURES MANUAL For Federal Lands Highway

Publication No. FHWA-CFL/TD-10-005



Central Federal Lands Highway Divisio 12300 West Dakota Avenue Lakewood, CO 80228





September 2010





Culvert Inventory and Condition Assessment





Retaining Walls Inventory and Condition Assessment

- Started with a custom inventory using ArcGIS Collector
- Migrated the inventory to ArcGIS Survey 123, and modified the template to incorporate the recommendations of publication "Retaining Wall Inventory and Assessment System"



Retaining Wall Inventory and Assessment System

William Rasdorf, PhD, P.E. Mohammed A. Gabr, PhD, P.E. Cedrick J. Butler, E. L Department of Civil, Construction, and Environmental Engineering North Carolina State University

Daniel J. Findley, PhD, P.E. Steven A. Bert, MPP Institute for Transportation Research and Education North Carolina Department of Transportation

NCDOT Project 2014-10 FHWA/NC/2014-10 September 2015

Retaining Walls Inventory and Condition Assessment



HIGHWAYS & TRANSPORTATION







- Inventoried, scanned, and georeferenced all geotechnical reports in SEO's library.
- Developed an app viewer for reports and borehole logs

Task 2 - Geotechnical Reports Database



Geotechnical Reports Database







HIGHWAYS & TRANSPORTATION



Geotechnical Reports Viewer



https://experience.arcgis.com/experience/f10a52a1325d482bbc99daba3baefe98



Boreholes Database



PUERTO RICO **HIGHWAYS & TRANSPORTATION** AUTHORITY

Municipality

Drilling start

Depth to grou

JSGS Quadrang

Ground elevation (m

Boreholes Viewer



https://experience.arcgis.com/experience/3a76d4e20c4948988a4e1e067221d4bf



Task 3 - Slopes Inventory

- Started with a custom inventory and rating system using ArcGIS Collector
- Migrated the inventory to ArcGIS Survey 123, and modified the template to incorporate the recommendations of publication "Unstable Slope Management Program for Federal Land Management Agencies"





January 2019







Slopes Inventory









- Limited resources due to the Puerto Rico financial crisis
 - Personnel
 - Equipment
 - Consultants
- Multiple challenges related to the physical characteristics of Puerto Rico (topography, geology, climate, etc.)
- Lack of knowledge of GAM by top management





- RFPs to collect data
- Incorporate a GAM plan into the PRHTA's overall TAMP
- Establish a procedure to request consultants to submit DIGSScompatible files for new geotechnical reports.
- Develop a policy for data exchange of GAM databases





Next steps (continued)

- Terrestrial laser scanning (TLS)
 - Detect rock movements
 - Characterize discontinuities
 - Develop an early warning system









Can TLS help the PRHTA's USMP?

- Case History 1 PR-615 Rockfall, Ciales (Center of the Island)
 - First event June 14, 2021
 - Second Event August 30, 2022
 - No rockfall monitoring system
 - Closed road
 - Relocation of residents
 - Press and public opinion
 - Geological characterization performed using traditional procedures







Figure 3. Photo shows rock fall scour movement direction, approximate path distance, and it's resting place between two houses adjacent to PR-615.



PR-615 Rockfall, First Event June 14, 2021



Figure 4. Close up of large boulder (rock fall) that fell and slid 300 linear feet along hillside, bounced on PR-615, and landed between two houses.



PR-615 Rockfall, Second Event August 30, 2022







Can TLS help the PRHTA's USMP? (continued)

• Case History 2 - PR-6 Rockfall (San Juan Metro Area)

- First event August 2013
- Second Event September 18, 2022, after hurricane Fiona
- No rockfall monitoring system
 - Closed road
 - Press and public opinion
- Geological characterization performed using traditional procedures





PR-6 Rockfall, First Event (August 2013)





PR-6 Rockfall, Second Event (September 18, 2022)







PR-6 Rockfall, Second Event (September 18, 2022)







Can TLS help the PRHTA's USMP? (continued)

- Clearly, a TLS can help our USMP
- Next steps regarding TLS
 - Acquire a TLS using STIC funds
 - Collect data from critical rock slopes selected from the SEO's USMP
 - Develop an early warning system protocol



Acknowledgements

- Southeastern Transportation Geotechnical Engineering Conference
- Mr. Benjamin Rivers, PE, Senior Geotechnical Engineer, FHWA
- Mr. Daniel Alzamora, PE, Senior Geotechnical Engineer/Team Leader, FHWA
- Mr. Andrés Álvarez, PE, Team Leader, Puerto Rico and US Virgin Island Division Office, FHWA
- Mr. Juan C. Rivera, PE, Highway Engineer, Puerto Rico and US Virgin Island Division Office, FHWA

Thank you!







Wikipedia contributors. (2022, August 26). Puerto Rico. In Wikipedia, The Free Encyclopedia. Retrieved 19:21, August 29, 2022, from https://en.wikipedia.org/w/index.php?title=Puerto_Rico&oldid=1106824248