# Geotechnical asset management: environmental sustainability and resilience

## Description

Federal rules in 23 CFR 515.9 encourage transportation agencies to incorporate in their Transportation Asset Management (TAM) Plans all infrastructure assets within the highway right of way. The focus is on National Highway System (NHS) bridges and pavements, but an agency may include geotechnical assets such as retaining walls, unstable slopes, embankments, and other asset classes whose functionality may affect the whole life cost and/or performance of the highway network. For the assets that a State voluntarily includes in its asset management plan, the State will not have to adhere to the asset management plan processes the State adopts for bridges and pavements.

Agencies with large investments in geotechnical assets, or with whose highway networks that are especially vulnerable to geotechnical hazards, may want to include in their TAM Plans a risk management strategy that analyzes geotechnical assets in a quantitative manner similar to what is often done with bridges and pavements. Such analysis could include quantitative performance measures for sustainability and resilience to measure project benefits and assist in prioritization and resource allocation of geotechnical asset investments such as risk mitigation, slope stabilization, reconstruction, and maintaining access to sustainable quantities of soil and rock for projects. Projects with positive impacts on environmental values or maintaining continuity of service would then be evaluated on a basis consistent with other preservation investments.

For the purpose of this research needs statement, the term “sustainability” refers to the effect of geotechnical assets, and of projects affecting such assets, on environmental values such as air quality, water quality, and cultural resources. The term “resilience” refers to the capability of a geotechnical asset to maintain its functions and structure in the face of internal and external change and to degrade gracefully when it must, avoiding the disruption of transportation service on a highway corridor.

In order to support this type of analysis, there is a need for performance measures and analysis tools to characterize the sustainability and resilience of geotechnical assets. These would need to be simple and consistent, able to be assessed visually in the field, supplemented with modern remote sensing techniques, sensitive to common agency actions, and clearly relatable to agency goals such as those enumerated in 23 USC 150(b). Tools would be necessary to associate changes in these measures with quantitative benefits compatible with life cycle cost analysis and suitable for benefit/cost prioritization.

## Objective

The objective of this research is to develop a clear, standardized set of definitions of sustainability and resilience performance that can characterize geotechnical assets. Methods will be developed and documented to perform field assessment, to forecast deterioration or other changes as applicable, to estimate the effects of common agency actions, and to estimate economic benefits of actions. The measures and tools will need to be field-tested by means of pilot studies, preferably with state DOT cooperation and the potential to implement the projects thus defined.

The definitions and methods shall be evaluated for consistency with existing databases or inventories, agency project prioritization methods, and existing or proposed level of service standards.

## Benefits

Using these measures and tools, agencies will have a consistent basis for site-based risk management that is fully-integrated with ongoing TAM business processes. Systematic and objective methods will ensure that geotechnical risks are managed consistently and fully considered in planning and programming.

## Related Research

NCHRP 24-46 is developing implementation guidance for geotechnical asset management, but is not expected to perform the research necessary to develop the quantitative measures and methods described here. NCHRP Project 20-07(378) has prepared a concept of resilience applicable to bridges, and a related set of analytical tools to assess the likelihood and consequences of service disruption scenarios. The framework may be adaptable to geotechnical assets, particularly the resilience and sustainability concepts and the structure of analysis tools, which tie the methodology to other standard resources such as the AASHTO Guide for User and Non-User Benefit Analysis for Highways (Red Book). Considering the apparent increase in unstable slopes causing service disruptions in steep terrain, tools to apply these concepts would be timely.

FHWA is developing a framework for implementing cross-asset tradeoff analysis that can integrate geotechnical assets into existing frameworks and systems for pavements and bridges. This can be used by agencies to implement a TAM Plan that includes geotechnical assets.

NCHRP Report 590 describes an approach for multi-objective optimization for bridge management that can integrate hazards and risk analysis into life cycle cost analysis, priority-setting, and resource allocation. This can provide one possible model, using the concept of utility functions, that may be applicable.

Many agencies have independently developed rockfall hazard rating systems, retaining wall inventories and assessments, and unstable slope management systems that build on visual assessments to characterize the vulnerability of geotechnical assets, but there is currently not a standard of practice for integrating this data into an asset management plan. Information that is collected is largely still managed with worst first or emergency reactive prioritization rather than evaluating life-cycle costs and economic benefits.

## Tasks

It is envisioned that the research will involve at least the following tasks:

1. Review and synthesize the relevant literature including the sources listed above and any other ongoing or completed work in the area.
2. Develop at least three alternative definitions of resilience and sustainability performance measures that can characterize existing geotechnical assets and the potential effects of agency actions, particularly maintenance, risk mitigation, preservation, reconstruction.
3. Prepare a Preliminary Report describing existing or developed definitions of resilience performance measures, including a case for and against each candidate performance measure. Solicit comments from the project Panel. Conduct a webinar with the Panel to decide the top two most viable definitions to proceed with more in-depth work.
4. For each of the top two viable alternative definitions of resilience and sustainability, develop a draft set of field assessment procedures, and calculation methods. Show how each possible measure might be tracked over time if it changes, how project benefits might be calculated in terms of the 23 USC 150(b) national goals and in terms of dollars of social benefit (to the agency, road users, and non-users).
5. Prepare an Interim Report describing the findings and recommendations of the preceding tasks. Solicit comments from the project Panel. Meet face-to-face with the Panel for one day to discuss the comments and proposed recommendations. Prepare a presentation for the Panel and lead discussions leading to final recommendations. Select one recommended measure for sustainability and one for resilience to advance.
6. Based on the Panel discussion and recommendations, develop a draft Guidelines document fully describing recommended measures, field procedures, assessment timelines and cycles, and calculation methods.
7. Pilot test the draft Guidelines document using a set of sites identified by cooperating agencies. This will require site visits and professional geological visual surveys similar to what agencies would be expected to perform routinely on their geotechnical assets. Gather necessary data and perform the calculations recommended in the draft Guidelines. Assess the usefulness of the results for all intended purposes including performance tracking, communication of project benefits, prioritization, resource allocation, performance target setting, and project programming.
8. Revise the draft Guidelines document based on what is learned in the pilot tests. Develop metrics to enable agencies to estimate and manage resource requirements for a routine field survey. Discuss the added benefits of the measures to transportation asset management. Provide recommendations on how to incorporate the measures into existing processes and systems including cross-asset decision making.
9. Prepare a draft Final Report describing the work that was done over the project. Submit the new draft Guidelines and draft Final Report to the Panel for review and comment. Conduct a webinar to discuss the final documents with the Panel.
10. Finalize and submit the Guidelines and Final Report based on Panel discussion.
11. Prepare and conduct a webinar to help federal, state, and local agencies to implement the Guidelines.

## Implementation

This research is envisioned to feed directly into TAM Plans and management systems for geotechnical assets. Continued FHWA and AASHTO support for asset management and performance management will help to ensure successful and widespread implementation.

Sponsoring Committee: AFP00(1) - Joint Section Subcommittee on Geotechnical Asset Management (AFP00 and AFS00)

Funding: $500,000

Research Period: 24 months

Research Priority: High

Date Posted: 01/11/2017

Index Terms: Geotechnical assets, asset management, risk assessment, resilience, sustainability