# 0-7091: Riprap Filters and Stability of Riprap Covered Slopes

## Background

Scour at bridges is a major cause of bridge failure. One common countermeasure for bridge scour and soil erosion is stone riprap, which is rocks placed around piers or on abutment slopes (Figure. 1).

## What the Researchers Did

The project focused on two main objectives:

- Determining if a filter is necessary between the riprap layer and the underlying soil and then recommending design and installation guidelines for riprap filters (granular and geosynthetic).
- Examining issues related to placing riprap on an abutment or riverbank slope and the associated stability of the slope and riprap.

Researchers first conducted an extensive literature review. Next, a survey was sent to all state departments of transportation, contractors, and associated entities to establish the current state of the practice. The researchers then performed laboratory testing. They finally collected riprap failure case histories and analyzed them to reach recommendations.

For filter assessment, laboratory tests were performed with the erosion function apparatus (EFA) to simulate experimentally the behavior of a soil, a geosynthetic filter, and a large gravel size riprap. The results of the three scenarios were compared. An existing design guideline was selected and edited, and design examples for both granular and geosynthetic filters were prepared.

**Figure. 1. Riprap Protection and Failure (Courtesy of John Delphia).**

To assess the stability of riprap-covered slopes, the researchers performed slope stability simulations using the RocScience Slide 2D software for geotechnical slope stability analysis

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(Bishop's simplified method). Also, a computational fluid dynamics–discrete element method analysis was performed to assess the effect of an increasing slope angle on the critical velocity of the riprap because most of the reported failures indicated riprap movement as the cause.

Finally, a set of case histories was collected from the literature review, the survey, and the Texas Department of Transportation (TxDOT) files to identify the causes of riprap failure.

## What They Found

The following are the main findings of this research:

- A filter is necessary in most cases to prevent erosion of the underlying soil.
- The main parameters in geotextile filter design are permeability, transmissivity, porosity, apparent opening size, percent open area, thickness, grab strength, tear strength, and puncture strength. The main parameters in granular filter design are particle size distribution, permeability, porosity, thickness, and durability.
- In most cases, a geosynthetic filter is preferable to a granular filter because geosynthetic filters are easier to install although they become harder to place underwater. Granular filters are more expensive than geosynthetic filters.
- Many techniques exist for filter installation and depend mainly on the type of filter, the contractor, and the project setting. Placing riprap and filters underwater is the biggest challenge.
- For slopes steeper than 1.5:1, the riprap is likely to fail. The steepest slope where riprap can be safely installed while meeting TxDOT design requirements is a: 2:1 slope (26.7 degrees).
- The critical velocity of riprap stones decreases with an increase in slope angle. The magnitude of the decrease can be significant and needs to be studied further.

## What This Means

Based on the study findings, the researchers recommend the following:

- Always use a filter under riprap for scour applications.
- Collect proper soil information prior to designing a filter.
- Use a geotextile filter unless it is obvious that a granular filter would be more appropriate.
- Avoid installing riprap on a slope that is steeper than 2:1. Be mindful that the critical velocity of riprap stones will be reduced when they are placed on slopes.
- Properly install riprap and filter to ensure the integrity of the system; place riprap stones rather than dumping them.
- Implement a proper monitoring program that will prevent major failures by identifying failure precursors at an early stage.
- Select the magnitude of the design flood carefully.

### For More Information

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