0-6935: Allowable Limit Contraction and Abutment Scour at Bridges

Background

Existing guidelines for maximum allowable scour are applicable only to piers since they are based on the stability criteria of the bridge foundations. An additional criterion must be considered when limiting scour at abutments where scour may also affect the stability of the approach embankment. Scour at spill-through abutments can cause slope stability failure of the embankment before reaching the depth endangering the foundations. This project proposed practical guidelines for determining the maximum allowable scour depth at or near spill-through abutments. This research primarily observed geotechnical failures of abutment embankments at multiple bridge sites in Texas.

What the Researchers Did

Researchers used a combination of review of the existing knowledge, a department of transportation (DOT) survey, study of case histories, analyses of different scour failure scenarios, and slope stability simulations accounting for possible ranges of influential variables to develop practical guidelines for allowable scour depth at abutments. The proposed guidelines and equations are verified against collected case histories. The review of existing knowledge proves that this research project is needed since very little information was found on allowable scour depths. The DOT survey shows the lack of well-defined recommendations for allowable scour depth at abutments. The analyses of possible scour failure scenarios show that the controlling failure mode of bridge abutments is slope stability failure of the spill-through embankment. For this reason, researchers performed over 50,000 slope stability simulations to find the scour depth causing slope stability failure at abutments with different geometries and soil types.

What They Found

Researchers conducted two types of analyses to study the slope stability of the scoured abutment under sudden drawdown with undrained soils condition: an effective stress analysis and a total stress analysis.

The failure sour depth Z_{Fail} results from the effective stress analysis are normalized by the total abutment height H and conservatively assigned to combinations of embankment and channel bed soil types (Table 1).

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Table 1. Maximum Allowable Scour Depth Based on the Effective Stress Analysis.

Embankment Soil Type	Channel Soil Type	Z_{Fail}/H	
		H = 10.5 ft	H = 20.4 ft
Clayey sand, SC	Cohesionless	0.3	0.16
	Cohesive	0.78	0.44
Silty sand, SM	Cohesionless	0.32	0.24
	Cohesive	0.81	0.48

Figure 1 presents the total stress analysis results in terms of Z_{Fail}/H versus $S_{uc}/\gamma H$ where S_{uc} is the channel bed undrained shear strength and γ is the soil total unit.

The maximum allowable scour depth should be the lesser depth found by the application of the proposed guidelines based on both the effective and total stress analyses (Table 1 and Figure 1).

What This Means

Bridge engineers and inspectors can easily follow the proposed equations and guidelines to judge the criticality of the measured or observed total scour at the abutments, including both contraction and local scour. The findings also provide a geotechnical approach to improving scour prediction at abutments. The slope stability failure of the abutment embankment increases the flow area and relieves the flow. Therefore, the existing abutment scour prediction equations that ignore this geotechnical failure are likely to overestimate the scour depth at abutments. Scour depths predicted using these equations can be limited by a maximum depth equal to the proposed maximum allowable scour depth.

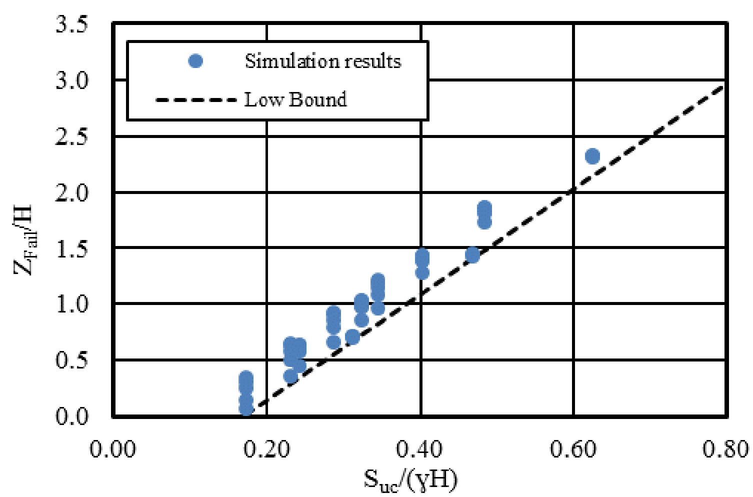

Figure 1. Z_{Fail}/H versus $S_{uc}/\gamma H$.

For More Information

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