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IMPROVEMENTS IN DESIGN SCOUR DEPTH PREDICTION

BACKGROUND

Over the past decade, great strides have been made in the ability to accurately predict design scour depths at simple bridge pier structures. Methodologies have also been developed for estimating design scour depths at piers with complex shapes. There are, however, areas where more analysis and more laboratory data are needed; for example, local scour at pile groups and buried pile caps.

Many bridge piers are complex in shape, consisting of several components (e.g., column, pile cap, pile group). The arrangement of the piles in the group and the pile spacing can vary from pier to pier, making it difficult to develop scour prediction equations that will cover all situations. The flow field and sediment transport (scour) processes in the neighborhood of pile groups are very complex and, thus, defy analytical or (computer) computational analysis. Predictive equations must, therefore, rely heavily on laboratory data. Additional data and analysis would allow improvements to be made to the complex pier scour prediction equations.

OBJECTIVES

The purpose of this project was to perform local scour experiments with pile groups, partially buried pile caps, and completely buried pile caps in flumes located in the Hydraulics Laboratory at the University of Auckland in New Zealand. Experiment data were analyzed and the results compared with predicted values using the complex pier local scour equations.

Specific tasks in this study included the following:

1. Conduct local scour experiments with partially and fully buried pile caps.
2. Conduct local scour experiments with pile groups with different orientations to the flow and with different pile spacing.
3. Reduce and analyze the data.
4. Compute the scour depths for the conditions of the tests using FDOT complex pier scour equations.
5. Determine if the equations need to be modified for the situations considered in the tests.

FINDINGS AND CONCLUSIONS

Based on the limited data that exists for partially and fully buried pile cap scour, it appears that the existence of piles beneath the pile cap (footer) actually reduces the scour depth (over what it would be if the piles were not there). Apparently, the piles in the scour hole retard the flow beneath the pile cap, thus reducing the shear stress and equilibrium scour depth.

Current design practice in Florida does not allow spread footers (without piles) pier design in erodable sediments. Nevertheless, there exist in Florida bridge piers with this configuration which the predictive equations must address. More buried and partially buried pile cap data is needed (with and without pile groups) before this phenomena can be properly quantified.

The research showed that existing equations accurately predict scour depths at complex piers consisting of a column, a pile cap, and a pile group with partially and fully buried pile caps. The equations also accurately predict scour depths for a column and footer as long as the footer is above the bed. However, the equations underpredict scour depths for piers with only columns and footers when the footer is partially or fully buried. Until this issue has been resolved, the following procedure should be used to compute design local scour depths at piers composed of a column and footer with no piles:

1. Compute the equilibrium scour using the existing equations in the Florida Scour Manual.

2. If the bottom of the pile cap/footer is not uncovered, use the computed scour for design.

3. If the pile cap/footer is uncovered (i.e. if the computed scour depth is greater than the distance from the bed to the bottom of the pile cap/footer), then multiply the computed scour depth by 1.35 to account for the increased scour due to the absence of piles.

BENEFITS

The results of this research are beneficial to all engineers using the Florida Complex Pier Scour Prediction Equations to determine design scour depths at bridge piers, in that they identify situations where the equations underpredict design scour depths. The report provides interim guidance regarding how to estimate scour depths in these situations. This research also identified the need to modify the equations to address spread footer designs in erodable sediments, which by current design standards are not allowed in Florida, but which are nevertheless present in some bridges still in service.

The improved equations will thus be useful for enhancing the safety of new bridge designs and identifying existing structures that will need countermeasures to prevent scour.

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