LAMAR UNIVERSITY

PROJECT SUMMARY

Texas Department of Transportation

0-6653: Hydraulic Performance of Rectangular Deck Drains

Background

The Texas Department of Transportation (TxDOT) Bridge Division has developed a new type of rectangular, scupper deck drain with two different sizes, 4″ × 8″ and 6″ × 8″. It allows runoff to drain via free fall without a pipe system. The new drain is designed to fit between the deck reinforcement and not interfere with the structural connection of the rail to the deck; therefore, it is less susceptible to clogging and requires less maintenance. However, no equation is available to accurately predict its hydraulic performance. Therefore, equations developed by Federal Highway Administration (FHWA) Hydraulic Engineering Circle 22 (HEC 22) for slotted drains were adapted to model its hydraulic performance. Two approximations have been made:

- The combined length of the rectangular drains in series are added without the intermediate concrete (1.5 feet) and treated as the length of a slotted drain.
- The different drain width between rectangular drains and slotted drains (2 inches) has been neglected.

It is believed that the use of the FHWA slotted drain equations is a poor approximation and does not predict the accurate capacity of the drains and the true ponding widths. It is necessary to evaluate whether the FHWA equation is accurate or a new equation should be developed to predict the hydraulic performance of the rectangular deck drain.

What the Researchers Did

A physical model was reconstructed to represent one lane of the bridge and was built to change the longitudinal and cross slope easily. Two different drain sizes, 4″ × 8″ and 6″ × 8″, were constructed of Plexiglass so that the behavior of the flow inside of the inlet can be observed. For each drain, 586 tests for the 4″ × 8″ drain and 236 tests for the 6″ × 8″ drain were conducted for a variety of longitudinal slopes (S_0), cross slopes (S_x), drain openings (N), and approach discharges (Q_a). Measurements in each test included the head on the V-notch weir from two reservoirs, and ponding widths (spread) and curb depths at a number of stations along the deck. The data measured from the physical model indicate that runoff capture is predicted by a weir-type equation. The data analysis was carried out using linear and non-linear regression methods.

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What They Found

The findings of this study are as follows:

- The physical study model showed the approach discharge reached normal flow before the drain openings. The dye tests illustrated the flow directions into the drain inlets, and flow into the drain behaves like flow over a weir. Therefore, water depth in front of the drain was a key parameter to determine the hydraulic performance. The hydraulic performance was the same for the 4″ × 8″ drain throughout the series since the water depth at the different openings were very similar, while it showed small decreases throughout the series for the 6″ × 8″ drain because the larger-width drains increased the capture discharge and decreased the water depth for the following drain opening.
- The investigation on the slotted drain method revealed the capture discharge calculated from their equation underestimated the capacity of the rectangular deck drains. The comparison indicated it is difficult to apply a correction factor for the adopted slotted drain method. Therefore, the slotted drain method is a conservative but not accurate method to use, and a new equation must be developed for the rectangular deck drain.
- A new equation has been successfully developed and has high agreement with the physical model data for both drain sizes. The capture discharge is the function of the approach discharge, Manning's roughness coefficient, cross slope, and longitudinal slope. This equation also indicated the capture discharge is proportional to the product of the number of the open drains, drain length, and drain width.
- Extensive data analysis using the IBM SPSS statistics data editor demonstrated the capture discharge is proportional to the drain length and drain width. It also revealed decreasing capture discharge along the flow direction, i.e., the power of the number of drains (N) is less than 1.

What This Means

The practical recommendations are as follows:

- The design criteria include approach discharge, drain size, maximum drain number, and bridge characteristics, such as Manning's coefficient, cross slope, and longitudinal slope.
- With the known bridge and deck drain characteristics, the 100% capture discharge can be determined.
- When the design approach discharge is less than the 100% capture discharge, the number of drains or size can be modified.
- When the design approach discharge is greater than the 100% capture discharge, the actual capture discharge and efficiency can be determined.

For More Information

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