0-6842: Analysis of Curb Inlets in the New TxDOT Standard Inlet and Manhole Program

Background

Curb inlets are installed to reduce water spread across a road. For efficient modular construction, TxDOT has provided a new standard for precast curb inlets outside roadway (referred to as PCO). Several questions arose within TxDOT about the hydraulic performance of PCO inlets because of the use of flush supports and restrictions in side bays. Standard design guidance for TxDOT projects is based on the Federal Highway Administration's Hydraulic Engineering Circular 22 (HEC-22), which does not have data that considers these issues.

What the Researchers Did

This project provides new design guidance for both PCO and non-PCO inlets. Three issues were investigated: 1) effects of structural slab supports, 2) inlet performance under various flow conditions and road slopes, and 3) effects of PCO flow restrictions on the interception. The researchers conducted the following tasks:

- Literature review on the effect of slab supports, existing design approaches, and collection of prior experimental data
- Modifications of an existing experimental facility and full-scale physical models constructed for a depressed curb inlet, and PCO inlet both on-grade and in a sag
- Experiments with 5-, 10-, and 15-ft depressed inlets on-grade: with and without slab supports, for three cross-sectional slopes and five longitudinal slopes, and for 100% interception and bypass flow conditions
- Developed a correction to HEC-22 equations for 100% interception capacity
- Developed a new relationship for flow interception when gutter flow is larger than inlet capacity

What They Found

Although HEC-22 states that flush slab supports will reduce inlet capacity, review of 22 prior studies from 1950-2012 yielded no evidence to support this claim. Our experiments confirmed there are no significant differences in the intercepted flow due to presence of slab supports.

The HEC-22 equations provide a reasonable estimate for the 100% interception flow for a 5-ft inlet (except for a very shallow longitudinal slope of 0.1%). However, HEC-22 significantly overestimates the 100% interception capacity of longer 10- and 15-ft inlets (both PCO and non-PCO). The HEC-22 equations assume a linear decrease in the water surface along the inlet length, which is incorrect for long inlets.

Regression analysis on experimental data provided a correction factor to the HEC-22 equations for the 100% interception flow of long inlets. The correction factor is a function of the depression geometry and upstream flow conditions. The value of the correction factor can be illustrated by considering "inlet efficiency," which is computed by HEC-22 as a

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function of the ratio between the length required to intercept the total gutter flow to the actual length of the inlet. The HEC-22 equations (without correction) applied to data from six studies showed significant data scatter and predictive error of 17.8%. With the new correction factor the data scatter was reduced and error was only 6.7%.

On-grade comparison of the conventional and PCO 10-ft inlets showed no significant effect on the inlet interception capacity caused by the PCO modular structure. Note that the 15-ft PCO inlet on-grade was not tested as this configuration should never be used; the 15-ft PCO on-grade requires a flow reversal in the downstream bay that will lead to clogging and significantly reduced capacity.

The sag configuration of the PCO inlet adds extension boxes on either side of a 5-ft inlet to create a 10- or 15-ft inlet. Results in a sag showed a sharp drop in the inlet performance below HEC-22 equations. The flow through the inlet of an extension is controlled by the PCO internal connection area rather than the inlet opening area. The interception of an extension in a sag is roughly 20% of the expected interception computed using HEC-22 design equations. It follows that the interception capacities of 10-ft and 15-ft PCO inlets are about 58% and 47% (respectively) of the expected capacity of a conventional inlet of the same length.

What This Means

1. One or two structural slab supports for 10-ft or 15-ft inlets (as in PCO and common conventional designs) have no significant effects on the interception capacity and do not need special design consideration.
2. HEC-22 design equations for 100% interception are adequate for common 5-ft depressed curb inlets (under most conditions), but dramatically underestimate the 100% capacity of 10-ft and 15-ft inlets under almost all conditions. The newly developed correction factor allows computation of the reduced inlet capacity. As a practical consequence, installing more short inlets at closer spacing is expected to perform better than a few longer inlets with longer spacing.
3. A 10-ft PCO inlet is effectively equivalent to a 10-ft conventional inlet under on-grade design conditions, but suffers from the same capacity degradation (relative to HEC-22 theoretical equations) as the conventional inlet, as noted above.
4. TxDOT should prohibit 15-ft PCO inlets from being used on-grade due to potential for clogging of downstream bay.
5. HEC-22 equations for conventional inlets in a sag conditions are valid, but capacities of PCO inlets in a sag are significantly reduced due to the hydraulics of the interior structural design. TxDOT should consider requiring conventional inlets in a sag as it is unlikely that the reduced capacity of the PCO inlets will make them effective.

Summary: Designers should be aware that both conventional and PCO-type inlets of 10 ft and 15 ft will not perform as predicted by HEC-22 design equations for on-grade installations. Furthermore, PCO inlets of 10 ft and 15 ft have severely degraded capacities in a sag.

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