Summary Report 1267-1(S)
June 1994

HYDRAULIC CHARACTERISTICS OF RECESSED CURB INLETS AND BRIDGE DRAINS

PROBLEM STATEMENT

The safety and maintenance problems associated with wet highways are well known: Precipitation, if allowed to accumulate as standing water, can cause vehicles to hydroplane, can cause deterioration of the pavement through water seepage, and can scatter sediment and debris across low-lying pavements. For uncurbed pavements, the problem is less critical, since water can simply flow off the road and into adjacent ditches. More problematic, however, are curbed roadways. For these types of facilities, the drainage of standing water is accomplished, ideally, by channeling the water along a gutter until it enters a curb opening or "inlet," after which it is carried away by means of an underground drainage system. On bridges, the water can follow a similar path, with the water designed to either fall from the bridge or be channeled through a pipe system.

There are various kinds of inlet structures, not all of them equally effective. Inlets constructed in curbs, for example, tend to be relatively effective because they are less susceptible to the clogging problems that plague those inlets structured as grates. Likewise, there are various kinds of bridge drains, the most common being the open scupper drains (which channel water off the bridge through free fall) and grate drains (which remove water through a system of drain pipes). Like curb inlets, these bridge drains tend to be more or less effective, depending on site-specific conditions.

But aside from the question of how well the various types of inlets and drains work, there is a more central problem. In Texas, as elsewhere, curb inlet and bridge drain designs are, for various reasons, frequently modified in ways that are not covered by the few existing design guidelines. Many recessed curb inlets and bridge deck drains are in fact constructed by simply referencing other such facilities in the immediate area—that is, without recourse to the kind of precise design data that would make the facility appropriate for the particular site. Consequently, openings in recessed curb inlets, for example, are sometimes constructed larger than necessary to compensate for the uncertainty regarding their maximum drain capacity. Unquestionably, facilities that are too large waste valuable public resources. Moreover, from an engineering standpoint, changes made in drainage facility geometry can affect hydraulic and flow capacity characteristics. The primary problem, then, is the need for definitive design data for constructing efficient and cost-effective roadway and bridge drainage facilities.

This issue was examined in a recent Center for Transportation Research report prepared by Edward R. Holley, Carl Woodward, Aldo Brigneti, and Clemens Ott, all of The University of Texas at Austin.

OBJECTIVES

The report, "Hydraulic Characteristics of Recessed Curb Inlets and Bridge Drains," documents the findings of Project 1267, a research study funded by the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA) through the Center for Transportation Research (CTR) of The University of Texas at Austin, with the actual research conducted at the Center for Research in Water Resources. The study had three objectives: (1) to determine the hydraulic characteristics of recessed curb inlets for different flow conditions and curb inlet geometries; (2) to determine the hydraulic characteristics of three types of bridge deck drains with different flow conditions and geometries; and, finally, (3) to codify this

DEPARTMENTAL INFORMATION EXCHANGE

CTR
in cooperation with
Texas Department of Transportation
and the FHWA

Summary Report

Office of Research and Technology Transfer
P.O. Box 5080 Austin, Texas • 78763-5080
Phone 512-465-7644
FAX 512-465-7486

information—through predictive equations for performance and capacity—so as to provide new design guidelines for the construction of both recessed curb inlets and bridge drains.

FINDINGS

The report presented its findings in two parts, the first part concerned with recessed curb inlets, the second with bridge deck drains. Regarding recessed curb inlets, the CTR team, following an initial literature review to determine existing sources of curb inlet designs, built a three-quarter-scale physical model of a recessed curb inlet, one whose cross slope and longitudinal slope could be easily changed. Water was pumped into the model through a system supplied from a half-million-gallon reservoir located outside the laboratory. Using the 10.5- by 64-foot model, the researchers conducted a total of 143 tests that evaluated the performance of curb inlets having different geometries and under varying flow conditions. Because most of the experiments were conducted in the laboratory, thirteen field tests using existing recessed curb inlets located around Austin, Texas, were undertaken to verify the lab results. In these tests, water from a nearby fire hydrant was released and its flow rates and depth measured. The study team found that, for the most part, the field tests confirmed the lab results.

The second phase of the study focused on identifying the capacity of three types of bridge deck drains, in this case a 4- by 6-inch rectangular scupper and two types of grate inlets. According to the authors, the objective of this set of tests was to obtain predictive equations for the drain capacity of each of these drains (commonly used in Texas), which in turn would lead to an "improved understanding" of the hydraulic principles that control this capacity. Following another literature review, the study team conducted experiments using the model previously used in the recessed curb inlet study (though here the model represented one traffic lane on a bridge deck). Again, tests focused on flow measurements and capacities of the various drains.

CONCLUSIONS

The conclusions for this report are presented separately, following each of the two portions of the study. Concerning recessed curb inlets, the study team tested three geometries of inlets and three inlet lengths (15, 10, and 5 ft). For the experiments, the researchers measured the flow rate into the recessed curb inlet, the flow rate passing the inlet section (the carryover), and water depths on the roadway surface. Accepting the conventional approach found in the literature that categorizes curb inlets as either 100 percent efficient or less than 100 percent efficient, the researchers were able to develop a new design equation (the "captured" flow divided by the gutter flow) in which a facility's efficiency is expressed as a function of the effective length of the inlet divided by the effective length required to capture all of the flow.

For all three bridge deck drains, regression analysis was used to determine the flow into the inlet as a function of the upstream uniform flow depth, the longitudinal roadway slope, and the cross slope. In this way, the study team obtained empirical equations for predicting the capacity for the flow conditions "most likely to be encountered on bridges."

Overall, the study has, as one reviewer noted, provided "useful design information." Additionally, the CTR team has identified important areas for future research regarding roadway and bridge drainage facilities.

Prepared by Ray Donley III
Center for Transportation Research
The University of Texas at Austin

The information provided in this summary is reported in detail in Research Report 1267-1F, "Hydraulic Characteristics of Recessed Curb Inlets and Bridge Drains," by Edward R. Holley, Carl Woodward, Aldo Brigneti, and Clemens Ott (November 1992). The contents of the summary report do not necessarily reflect the official views of the FHWA or TxDOT.