KANSAS DEPARTMENT OF TRANSPORTATION

TECHNICAL SUMMARY

A MODEL STUDY OF BRIDGE HYDRAULICS, EDITION 2

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Introduction

Most flood studies in the United States use the Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS) computer program. This report is the second edition. The first edition of the report considered the laboratory model to be distorted with 1:100 horizontal scale and 1:20 vertical scale. The second edition considers both distorted and undistorted interpretations of the laboratory models. Moreover, more advanced HEC-RAS modeling techniques are used to better match the HEC-RAS and the laboratory results. The advanced HEC-RAS models were based on review comments and model revisions by Mr. Gary W. Brunner, Senior Technical Hydraulic Engineer, Hydrologic Engineering Center (HEC).

Project Objective

This study was carried out to compare results of HEC-RAS bridge modeling with laboratory experiments. A laboratory flume was constructed specifically for this purpose in which nine experiments were performed for each bridge type for a range of flow and tailwater conditions.

Project Description

The experimental set-up used in this study was designed to simulate a typical "real-world" bridge. It included roadway embankments, bridge deck, guard rails and piers.

This study investigated bridge hydraulics for floodplain channels. Laboratory and HEC-RAS modeling were performed for three bridge scenarios for a range of discharge and tailwater conditions: Type 1 - General Bridge Modeling, Type 2 - Combination Bridge/Weir Flow, and Type 3 - Skewed Bridge.

Three different discharges were tested for each of the experiment types. The tailwater elevation was also set at three different values for each discharge. Thus, a total of 27 laboratory tests conditions were studied.

HEC-RAS models were created to simulate the flume data at prototype scales for the assumptions that the laboratory model was (a) undistorted and (b) distorted. Froude number similarity was used to provide "prototype" geometry and discharge. The undistorted HEC-RAS models were based on the assumption of a constant 20:1 model ratio. This means that all geometric dimensions in the model were assumed to be 1/20-th of the prototype dimensions. The distorted modeling was based on the assumption of horizontal and vertical modeling scales of 100:1 (Xr) and 20:1 (Xr), respectively. Thus the vertical and horizontal model dimensions were assumed to be 1/20-th and 1/100-th, respectively, of the prototype dimensions.

Project Results

The headwater for the Type 1 Regular and Modified HEC-RAS models agreed very well with the laboratory experiments for the low discharge experiments. For the middle and high discharge conditions the HEC-RAS results tended to collapse to a single profile upstream from the bridge implying that HEC-RAS considered the bridge to be under inlet control with critical flow through the bridge. The headwater for the middle and high flow laboratory experiments distinctly showed the effect of the tailwater.

The Modified HEC-RAS Type 2 models were much better than the Regular HEC-RAS Type 2 models for all flows. The Modified model profiles upstream from the bridge again collapsed to a single curve for each discharge, implying inlet control at the bridge. The laboratory experiments again showed tailwater effects for all discharges. The agreement between the laboratory headwater and the Modified model headwater was good for the low and middle flows but about 2-feet higher for the high flow.

The Regular and Modified HEC-RAS Type 3 models were both in good agreement with the laboratory data for the low flow conditions. The Modified model was much better than the Regular model for the middle and high flows. The Regular model was improved by choosing zero skew for the bridge and bounding cross sections directly upstream and downstream from the bridge.

Report Information

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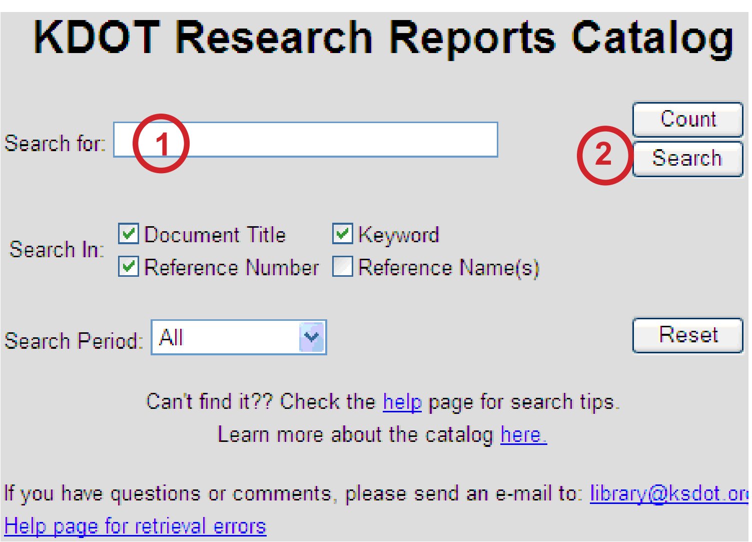

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