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BRIDGE SCOUR DATA MANAGEMENT

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Abstract

A Bridge Scour Data Management System has been developed by the U.S. Geological Survey to support preparation, compilation, and analysis of bridge scour measurement data. Users may interactively store, retrieve, select, update, and display bridge scour and associated data. Interactive processing makes use of full-screen menus and form fill-ins, and an instruction window. Optional help and limits windows provide additional information for each of about 150 items in the data set for each bridge-scour site. The data set items include all of the essential information from a detailed scour measurement. Each data set has four categories of information: site data; measured scour data; flood event data; and channel geometry data. Program options permit selection of prediction equations and computation of scour depth estimates for comparison with observed scour depths. The program is written in Fortran 77 and is portable to personal computers, workstations, and minicomputers. The data base will facilitate: (1) developing improved estimators of scour for specific regions or conditions; (2) describing scour processes; and (3) reducing risk from scour at bridges.

Introduction

About 84 percent of the bridges in the United States are over waterways. A survey of U.S. bridge failures since 1950 reported by Shirole and Holt (1991) show that of 823 failures surveyed, 60 percent were associated with hydraulics (figure 1), which includes channel bed scour around bridge foundations and channel instability. The Federal Highway Administration (FHWA) Technical Advisory 5140.20 states: "Most waterways can be expected to experience scour over a bridge's service life (which is now

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approaching 100 years)....The added cost of making a bridge less vulnerable to scour [through research, countermeasures, etc.] is small when compared to the total cost of a failure which can easily be two or three times the original cost of the bridge itself." Improved scour design techniques requires better data and understanding of scour processes. Scour processes have been extensively researched using laboratory model studies. This research has provided valuable data and understanding. However, scour predictions based on model results vary considerably, probably due to dynamic dissimilarity and other factors not duplicated in most laboratory models. It has long been recognized that field measurements of bridge scour are needed to broaden our ability to understand and predict bridge scour. A considerable ammount of historic scour data exists in the files of hydrologic data collection agencies such as the U.S. Geological Survey (USGS). Field measurements of local scour have been compiled by Froelich (1988) and by Zhuravljov (1978). These historical data sets contain valuable information, but most do not contain information on all of the factors known to affect scour. Scour data are now being collected (at various levels of effort) in more than 20 states by the USGS in cooperation with State highway agencies. A portable and interactive computer data base management system is needed to support preparation, compilation, and analysis of bridge scour measurement data. This data base management system is also needed to facilitate both regional comparisons and long term storage of bridge scour investigation results. This paper describes a Bridge Scour Data Management System (BSDMS) being developed to support these needs. At the writing of this article, the BSDMS has been beta tested and revisions are underway for the prototype system.

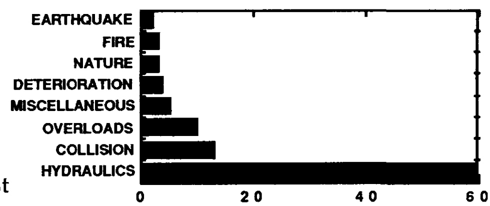

Figure 1.-- Percent of bridge failures by failure mode

The BSDMS supports bridge scour data set preparation by providing a complete, formatted list and description of the data elements which should be included. The program features interactive menu and form fill-in screens with on-line help information (Kittle, 1989). The utility of data sets will be enhanced by the use of a uniform, portable data base system, by the periodic compilation of data entered into the system, and by redistribution to those conducting scour investigations and research. A significant function of BSDMS is to serve as a long-term repository of scour data to which future measurement data will be added. The BSDMS has been developed by the USGS National Scour Study, in cooperation with the Federal Highway Administration.

Characteristics and Capabilities

The basic functions of the BSDMS are data archival and retrieval. The principal features are portability and ease of use. The program enables users to interactively store, retrieve, select, update, and display bridge scour and associated data. User interaction features full-screen menus and form fill-ins, including prompts, help information, and default values. The program is written in Fortran 77 and is portable to microcomputers, engineering workstations, minicomputers, and mainframes. The data are stored in an unformatted, direct-access file with pointer systems and chaining for rapid access to the data and for efficient management of disk space following data editing and deletion. Data-management functions enable a user to add, delete, or modify data sets. Elements within data sets can be selected and modified or copied from one data set to another. Search and selection of data sets are based on user-specified criteria of data element values or value ranges. Data sets in the data base which satisfy search criteria will be added to a buffer for further processing. Graphic capabilities include plotting the location of selected sites on an outline map of the United States. Hydrograph and cross-section data also may be plotted. Information from all or selected data sets can viewed interactively and can be exported for archiving or to be read by separate programs for statistical analysis.

Table 1.-- Bridge Scour Data Base System data structure

SITE DATA	SCOUR MEASUREMENT DATA	FLOOD EVENT DATA	CHANNEL GEOMETRY DATA
Location Data	Pier Scour	Peak Stage	Reference Coordinates
Site Description	Abutment Scour	Peak Discharge	Channel Geometry
Elevation Data	Contraction Scour	Hydrograph Data	
Stream Data	General Scour	Debris Data	
Bridge Data			
Abutment Data			
Pier Data			

A computational option will enable users to select equations for estimating scour depths and to compare estimated and observed scour depths. A limited number of equations are included for estimation of local pier scour, local abutment scour and contraction scour. The list of equations is tentative and may be supplemented as additional field data becomes available and better equations are developed. These equations will include those listed in FHWA's HEC-18 (1991). The equations should only be applied to streams characteristic of the conditions for which the equations were developed. Some sites will not be represented by any of the equations.

```
+-Site (ESi)-----------------------------------------------------------------+
|            Select a Site edit option.                                      |
|                                                                            |
|            Location   - edit geographic location parameters               |
|            Elevation  - edit elevation type and difference                |
|              Stream   - edit various stream parameters                    |
|            Bridge     - edit bridge definition parameters                 |
|            Abutment   - edit abutment definition parameters               |
|            Pier       - edit pier definition parameters                   |
|            Contact    - edit contact and publication references           |
|            Return     - to the Edit screen                                 |
+----------------------------------------------------------------------------+
+-HELP-----------------------------------------------------------------------+
|        Select this option to edit the general stream parameters            |
|        associated with the site, such as geomorphic factors, bed           |
|        material characteristics, etc.                                      |
|                                                                            |
+----------------------------------------------------------------------------+
+-INSTRUCT-------------------------------------------------------------------+
|                     Type the first letter of an option or                  |
|                       select an option using arrow keys                    |
|                 then confirm selection with the Next command.              |
+----------------------------------------------------------------------------+
Help:F1   Next:F2   Quiet:F8
```

Figure 2.-- Example Menu Screen from BSDMS

When comparing observed and computed scour depths it must be noted that these equations were developed principally for bridge design. Thus the equations have been developed with criteria based upon conservatism rather than accuracy. The goal of accuracy, rather than conservatism may be investigated in developing new equations. Designers could then apply risk analysis to determine a factor of safety based on equation accuracy, average daily traffic, or other variables.

Structure and Elements of Data Set

The structure of a data set in the BSDMS is shown in Table 1. There is insufficient space here to describe the approximately 150 variables in a data set for a given bridge site. All of the data for a bridge site will be stored in a single data set. Each data set has four categories: site data; scour measurement data; flood event data; and channel geometry data. Channel geometry data include coordinate reference information, 3-dimensional channel geometry data, and time of measurement data. For each site there may be several sets of channel geometry data, and/or several flood events.

For each flood event there may be several sets of scour measurement data. The BSDMS is designed to store all of the essential information from a detailed scour measurement; however most data sets are more limited and do not contain all of the information which can be stored.

Operation

The BSDMS features full-screen menus and form fill-ins, providing prompts, help information, and data element limits and defaults. For any particular screen, prompts may be issued in one of three formats: (1) menu selection for processing options; (2) form fill-ins in which a form is written on the screen and responses are made at highlighted locations; or (3) a table format to input or update values in rows and columns. Extensive help functions are an integral feature of the program. A window near the bottom of the screen provides general instructions for processing the particular screen. Additional help can be obtained by selecting help or limits from the command line at the bottom of the screen. Thus, beginning users can obtain detailed descriptions of data elements, of the data base operation, and of the equations in the analysis option. Figure 2 shows a Site Data menu screen. The Help box is activated and the help information is automatically displayed for the selected (Stream) option. Figure 3 shows a form fill-in screen for measured local pier scour data. The help information displayed is for the selected (Depth) option. Additional assistance is provided the new user with a tutorial which guides the user through the system with small pop-up boxes of instructions.

```
+-Scour (EScSc)--------------------------------------------------------------+
|                                                                             |
|        <------ Local Scour Hole --------> <--Approach Flow->                |
| Pier    Maximum   Depth      Side    Top    Velocity   Depth     Sediment   |
|  ID      Depth   Accuracy    Slope   Width                        Transport |
|   1        2.1      0.5       1.4    4.0       3.2      5.9       LIVE     |
|   2       10.0      1.0       2.0   26.0       7.5     21.0       LIVE     |
|   3       14.0      1.0       1.5   31.0      10.8     18.5       LIVE     |
|   3A       6.5      1.0      n.a.   n.a.       4.4      7.3       LIVE     |
|                                                                             |
+-----------------------------------------------------------------------------+
+-HELP------------------------------------------------------------------------+
|  Units: ft                                                                  |
|  Enter the flow depth in approach section upstream from pier scour hole for |
|  the time of the measurement.  This may be estimated as the flow depth at   |
|  the scour hole, minus the measured local scour.                            |
+-----------------------------------------------------------------------------+
+-INSTRUCT--------------------------------------------------------------------+
|                     Enter data in highlighted field(s).                     |
|   Use carriage return or arrow keys to enter data and move between fields.  |
|       Use 'Next' command to go to next screen when done entering data.      |
+-----------------------------------------------------------------------------+
Help:F1   Next:F2   Prev:F4   Limits:F5   Quiet:F8   Oops   Window   Uppg
```

Figure 3.-- Example form fill-in screen from BSDMS

Summary

A Bridge Scour Data Base system (BSDMS) has been developed to support preparation, compilation, and analysis of bridge scour measurement data. The primary functions of the BSDMS are data archival and retrieval. Data base elements include the essential information for a detailed scour measurement. Data base elements are categorized as site data, scour measurement data, flood event data, or channel geometry data. Users will be able to store, modify, and retrieve bridge scour data. An analysis option will enable users to compute estimated scour depths for selected data sets from user-specified equations. User interaction will be full-screen menus and fill-ins with help options. Preparation and compilation of data sets will be supported by a uniform and complete list and description of bridge scour data set elements and by the availability of a uniform, portable data base system specifically for this data. The BSDMS is an important element in attaining the goal of reduced risk from scour processes at bridges.

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