Subject Areas: IIC Bridges, Other Structures, Hydraulics   Responsible Staff Officer: Lloyd R. Crowther
and Hydrology; IIIA Soils, Geology, and Foundations

BRI-STARS (BRIdge Stream Tube Model for Alluvial River Simulation)

An NCHRP digest of the results of NCHRP Project 15-11, "Computer-Aided Analysis of Highway Encroachments on Mobile Boundary Streams," and NCHRP Project 15-11A, "BRI-STARS Maintenance Support and Enhancement," prepared by Lloyd R. Crowther. It describes an innovative, operational computer program capable of simulating channel widening/narrowing phenomenon and local scour caused by highway encroachments, which should be of interest to both bridge and hydraulic engineers.

THE PROBLEM AND ITS SOLUTION

Most of the 484,000 bridges in the National Bridge Inventory that are constructed over waterways are subject to various degrees of scour and lateral stream migration (erosion) during floods. In addition, many miles of highways are built along and encroach on streams. Engineers realize that streams can degrade, aggrade, and change location within floodplains and that the actual construction of a bridge or highway may initiate additional morphological changes in the behavior of a stream. However, existing design procedures for highway structures assume for the most part that streams have fixed boundaries. Although state-of-the-art analyses are available for the mobile boundary stream condition, they are seldom used, and if assessments are accomplished at all, they are based primarily on the designer's judgment and experience.

At the Transportation Research Board's Second International Bridge Engineering Conference in Minneapolis in September 1984, a thorough review of existing computer models available to aid in analyzing mobile boundary streams was undertaken.

The review found that the available analytical procedures were difficult to use and had not been adapted to highway applications. The reviewers concluded that none of the existing models was totally suitable to aid either in designing highway bridges or in determining the effects of longitudinal encroachments. Some of the existing models applied only to long stream reaches, others were not detailed enough for bridge openings and did not predict lateral erosion of streams, and many were not user friendly.

NCHRP Project 15-11

NCHRP Project 15-11 was initiated to address this problem. The objective of the research was to develop and test a practical computer model. This model was to be based on sound physical principals of flow and sediment interaction and designed to estimate water-surface profiles, aggradation, degradation, scour, and bank widening resulting from bridges and longitudinal encroachments located on mobile boundary streams. These estimates were intended to be used to aid in the design of highway crossings or other stream encroachments.

In response to this objective, Dr. Albert Molinas, co-principal investigator of NCHRP Project 15-11, created a computer program titled BRI-STARS (BRIdge Stream Tube Model for Alluvial River Simulation) and a companion expert system program for stream classification. In 1990, the NCHRP concluded that the project had been successful, but that further work was necessary to ensure a fully operational computer software package and to further enhance the product. This additional effort was undertaken as NCHRP Project 15-11A, "BRI-STARS Maintenance Support and Enhancement."

NCHRP Project 15-11A

The goals of this second project were to provide a series of NCHRP Project Panel-mandated enhancements, to establish an electronic bulletin board for discussion between Dr. Molinas and the users who were testing the model (the maintenance element of the project), and to conduct a BRI-STARS workshop for further dialogue between the program's author and selected users.

The enhancement activity accounted for 75 percent of the project's budget and represented a comparable share of the additional effort. Unfortunately, the bulletin board received almost no use. The workshop—held in August 1992 at Colorado State University, Fort Collins, CO—was well received and resulted in suggested improvements for Dr. Molinas to consider.

BRI-STARS

BRI-STARS version 3.3 for DOS is the end result of the NCHRP Project 15-11 series of research projects. The Federal Highway Administration (FHWA) has negotiated a contract with Dr. Molinas to enhance and extend the BRI-STARS program. FHWA plans to distribute BRI-STARS through *McTrans* in a Windows™ format upon contract completion, scheduled for late 1997.

BRI-STARS is a semi-two-dimensional model capable of computing alluvial scour/deposition through subcritical, supercritical, and a combination of both flow conditions involving hydraulic jumps. This model, unlike conventional water- and sediment-routing computer models, is capable of simulating channel widening/narrowing phenomenon as well as local scour resulting from highway encroachments. It couples a fixed-width stream tube computer model, which simulates the scour/deposition process taking place in the vertical direction across the channel, with a total stream power minimization algorithm. The decision-making algorithm, using rate of energy dissipation or total stream power minimization, determines whether the simulated sediment erosion satisfying the sediment continuity equation should take place in the lateral or vertical direction. It is this second component that allows the lateral changes in channel geometries. Finally, the bridge component allows computation of the hydraulic flow variables and the resulting scour from highway encroachments. The model also contains a rule-based expert system program for classifying streams by size, bed and bank material stability, platform geometry, and other hydraulic and morphological features.

Operating BRI-STARS

With the recent enhancements, the memory requirements for BRI-STARS version 3.3 have reached 596K of Random Access Memory (RAM). Under the DOS 640K memory limitation, users must configure their systems to free at least 600K of available memory for model execution. For DOS 5.0 and above, there are a number of ways users can configure their systems to accommodate this requirement. The README file, contained on both the first and third BRI-STARS disks, contains three typical installations that Dr. Molinas found operational, i.e., provided sufficient RAM to execute the program. They are as follows: a) DOS 5.0 with QEMM memory manager; b) DOS 6.2 with HIMEM memory manager; and c) DOS 6.2 with DOS memory manager and DoubleSpace compressed hard disk.

NCHRP has been able to operate the program on an IBM compatible 486 DX using MS-DOS 6.0 and the following file modifications:

AUTOEXEC.BAT FILE
@ ECHO OFF
CLS
PATH C:\DOS
BREAK ON
PROMPT pg

CONFIG.SYS FILE
DEVICE=C:\DOS\HIMEM.SYS
DOS=HIGH, UMB
DEVICEHIGH=C:\DOS\ANSI.SYS
FILES=20
BUFFERS=20

The above files were created on a floppy disk containing the DOS system files (C>FORMAT A:/s). The BRI-STARS program was installed on drive C. By warm-booting the computer (pressing Ctrl-Alt-Del) with the floppy disk inserted in its proper drive, all computer network connections were eliminated and the available free memory increased from 474K to 616K. When the prompt was changed from A> to C> and the BRI-STARS directory retrieved (CD\BRISTARS), the program started using the command BST.

The BRI-STARS program functions properly using the method previously described, but the results cannot be printed in this mode at NCHRP because all NCHRP printers operate through a network print server. However, because BRI-STARS saves everything to files, the data remain in the program. The files can be printed by warm-booting the computer again with the floppy disk removed and reentering BRI-STARS at the C> prompt because printing or transferring files is not a RAM-intensive operation.

Obtaining BRI-STARS

BRI-STARS is available for distribution with full version support from *McTrans* (telephone 904/392-0378). It consists of three double-density 3½-in. disks. *McTrans* can also provide the *User's Manual for BRI-STARS*, March 1994, prepared by Dr. Molinas as part of NCHRP Project 15-11A. Also included in this document is the *User's Manual for the BRI-STARS Expert System for Stream Classification*. A copy of this material has been provided to each state.

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