NAVIGATION MODEL STUDY IMPROVES RIVER SAFETY OF NEW BRIDGE

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The U.S. Army Corps of Engineers Waterways Experiment Station (WES) conducts studies for most of the Corps' projects involving new waterway designs, as well as proposed modifications to existing federally authorized navigation projects. These studies generally include testing the waterway design with regard to safe operation, and developing alternative designs to improve safety and make the project more efficient and cost-effective. The studies are normally accomplished using scaled physical models of the project waterway or mathematical models operating on the WES Ship/Tow Simulator (see *TR News* 177, March–April 1995, pages 30–31).

Problem

During 1988–1994, WES performed a physical model study aimed at improving navigation conditions and maintenance for the channel upstream of the U.S. 82 Greenville Bridge across the Mississippi River connecting Mississippi and Arkansas. The Greenville Bridge reach has one of the highest accident rates on the Mississippi River system. As part of the WES study, tows approaching the bridge from upstream were recorded on time-lapse videotape in order to monitor navigation conditions and operations during the construction phase of the Greenville Reach Navigation Project.

In 1995 the Mississippi Department of Transportation began designing a replacement for the Greenville Bridge. The new three-span cable-stayed bridge is to be located 850 m downstream of the existing bridge. The new structure has two piers located in the water and a navigation span 420 m wide, whereas the existing structure has four piers in the water and a navigation span 256 m wide in the center. MDOT and its design consultant, HNTB Corporation, approached the Corps about using the Greenville Bridge Reach Model to evaluate the navigation safety of the proposed bridge design, especially since the channel was being modified to improve the upstream approach to the old bridge. It was necessary to determine whether the same level of safety could be expected with the new bridge once the Corps' navigation project had been completed.

Solution

In response to the MDOT request, WES undertook a study of the new Greenville Bridge design. This study had to address several key questions: What location and size are best for a navigation span through which tows can safely navigate? What should be the design load on the piers for an impact by a large Mississippi tow? What are the magnitude and direction of the currents that may erode the channel around the bridge piers?

The 1:150 scale, semifixed bed model was modified to remove the old bridge, add the new bridge, and replicate 13.4 km of the Mississippi River. A scale model of a 35-barge tow (53.3 m wide and 447 m long and loaded to a 2.7 m draft) was operated through five flows ranging from 5,250 m^3/s (0-m stage on the Greenville gage) to 42,500 m^3/s (12.5-m stage). The position, orientation, and speed of the tow and the currents in the upper 2.7 m of water were measured using a video tracking system. Two-dimensional velocity measurements were made near the bottom of the piers with a miniature velocity probe. Time-lapse videotapes of actual tow traffic approaching the existing Greenville Bridge were reviewed to develop a distribution of tow sizes and approach velocities for use in designing the piers to sustain potential tow impact loads.

Application

The model tow transits indicated that safety at the proposed bridge site could be improved if the navigation span were moved 45 m to the west. During high flows, currents tended to push transiting tows toward the western pier. Review of the bridge

design revealed that 30 m was the maximum distance the navigation span could be moved without significantly impacting the cost and difficulty of building the bridge. Examination of the navigation conditions with this modification showed that safety was significantly improved; therefore, it was decided to relocate the navigation span 30 m to the west. Representatives of the U.S. Coast Guard 8th District and members of the Lower Mississippi River Committee (an industry action group functioning as an advisory committee to the Corps of Engineers and the Coast Guard) reviewed the study results and recommendations and concurred with the proposed relocation.

The velocities measured at the foot of the model piers indicated that the currents would approach the piers at an angle; the initial bridge design had assumed that the currents would be parallel to the pier. Revised computations of river scour were made using the measured velocity magnitudes and angles, and improved estimates of the necessary allowance for bed scour were incorporated into the bridge pier caisson design.

Benefits

Because the replacement bridge design was in its initial stages, the design changes made in response to the WES study had a minor impact on the cost estimates for the project. However, if this information had not been available until later in the design process, the cost of making changes to obtain a safer design could have been significant.

Use of the WES Greenville Bridge Reach Model in this study demonstrated that the new bridge will provide improved navigational and structural safety for several reasons. First, the relocation of the navigation span will greatly reduce the potential for the piers to be struck by a large Mississippi River tow. Second, the piers will be designed to withstand the potential impact of tows of a size known to move through this river reach. Finally, the pier caisson will be designed to accommodate the proper amount of riverbed scour.

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Suggestions for "Research Pays Off" topics are welcome. Contact G. P. Jayaprakash, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 (telephone 202-334-2952; e-mail gjayapra@nas.edu).

Aerial photograph of Greenville reach on Mississippi River with northbound barge traffic in foreground, existing U.S. 82 bridge removed, and sketch of new three-span cable-stayed bridge superimposed.