U.S. Department of Transportation
Federal Highway Administration

Hydraulic Model Determines Cost-Effective Flood Mitigation

Problem

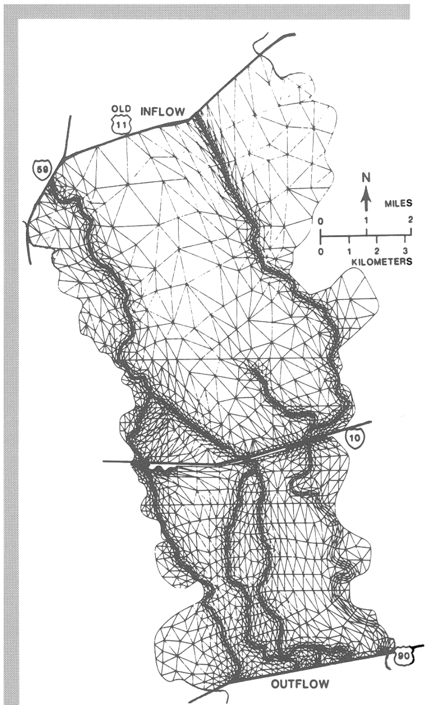
The lower Pearl River basin in Louisiana has experienced a flood-of-record three times between 1979 and 1983; that is, each of the three successive floods was larger than any previously recorded. Flood damage was severe for those inhabiting the 4- to 5-mile wide floodplain near Slidell, Louisiana. At that location, the river divides into several channels that meander across the floodplain, and there is considerable encroachment by residential development.

As a result of the floods, along with the U.S. Army Corps of Engineers, the U.S. Geological Survey, and the FHWA, the Louisiana Department of Transportation and Development (DOTD) was confronted with a list of specific demands for action by a well-organized and well-prepared coalition of citizens. The Military Road Alliance (MRA) demanded some 3,000 ft of additional bridge opening on I-10, with commensurate additional openings on the downstream (US-90—US-190) highway system, for the purpose of flood-damage mitigation.

Upstream of I-10, residents were concerned that the highway constricted flow, creating a backwater condition that caused or aggravated flood damage. Downstream of I-10, residents also expressed concern that their own flooding situation might be worsened if additional openings were provided for the relief of those above I-10. In addition, they believed that they were being damaged by backwater from the US-90—US-190 crossing, parallel to, but downstream of, the I-10 crossing. From a highway perspective, the issues were: How many bridges, how large, where to locate them, and what should be the appropriate basis for structural modifications to a highway facility by an agency with funds allocated primarily for transportation purposes and not for flood control?

Solution

In 1984, through the local office of the U.S. Geological Survey, the Louisiana DOTD applied a computerized model to analyze flood profiles in the Pearl River basin. The model, the result of more than 10 years of FHWA-sponsored research and development by government agencies and private organizations, uses a finite element grid to permit a horizontal, two-dimensional analysis of flow through the floodplain and its constrictions. It accounts for multiple-bridge openings, overtopping of the roadway embankments, differential vegetation densities, multiple channels, complex landforms, and virtually every other type of floodplain complexity that had rendered the Pearl River problem unmanageable by conventional techniques.



Finite-element network for the lower Pearl River floodplain.

Application

The analytical model was calibrated against recorded data and used to evaluate various combinations of both structural and nonstructural mitigations. Nonstructural actions, which included clearing of brush and vegetation, removal of a spoil island downstream of the west bridge opening, and excavation under existing bridges, would com-

bine to provide nearly a 0.5-ft reduction in backwater near the western bridge opening, the side of the floodplain where developed property was most heavily affected.

In addition to the nonstructural measures, several alternative bridge configurations were tested. Although the public demand had been for some 3,000 ft of additional opening, bridge openings of 1,000 ft and 2,000 ft were tested in conjunction with the other measures. The results were surprising. The addition of the 1,000-ft bridge produced a total of 1 ft in backwater reduction (separate from the non-structural options), whereas the placement of a second 1,000-ft bridge increased the total backwater reduction by only 0.1 ft.

The results were equally, if not more, surprising when the model was also used to evaluate alternative mitigations in the lower highway system. Simply stated, the model showed that the flood profile was not responsive to additional bridge openings in the lower highway system.

Benefits

The Louisiana DOTD is now proceeding with plans for construction of an additional 1,000-ft bridge opening on I-10 and an additional 250-ft bridge opening on US-90—US-190. The estimated savings may be between $5 and $10 million. As previously stated, the original demand was for as much as three times the amount of additional bridge opening as that finally selected. Even the Louisiana DOTD engineers expected that more bridge openings would be required. The overwhelming benefit of the computer model analysis was that it provided a credible basis for engineering decisions of tremendous economic, as well as volatile social and political, significance.

The model is being used by other state highway agencies and will probably replace less sophisticated methods—even for routine water-surface profile calculations—as user enhancements continue to simplify the application of the model.

For further information, contact Dr. Roy E. Trent, Federal Highway Administration, HNR-10, 6300 Georgetown Pike, McLean, Virginia 22101-2296 (703-285-2440); or Henry Barousse, Hydraulics Engineer, Louisiana Department of Transportation and Development, P.O. Box 44245, Capitol Station, Baton Rouge, Louisiana 70804 (504-379-1306). The two-dimensional model "Finite Element Surface Water Modeling System" (FESWMS) may be obtained by contacting local offices of the U.S. Geological Survey or Dr. Roy E. Trent.

Suggestions for "Research Pays Off" articles are welcome. Contact Nancy A. Ackerman, Editor, TR News, Transportation Research Board, 2101 Constitution Avenue, N.W., Washington, D.C. 20418 (telephone 202-334-2972).