Project Summary

Texas Department of Transportation

0-4378: Establish Guidance for Soils Properties-Based Prediction of Meander Migration Rate

Background

The main channel of a river will migrate and will rework its flood plain from time to time. The Texas Department of Transportation (TxDOT) has long monitored existing river paths and potential threats to highway bridges and other near-bank structures. A method to accurately predict future river location is needed to protect and plan for such structures in Texas.

The purpose of TxDOT Project 0-4378, *Establish Guidance for Soils Properties-Based Prediction of Meander Migration Rate*, was to develop a method for estimating river migration distances and forecasting the future location of rivers. The full project report includes a literature review, case histories, a methodology, details on large-scale flume tests, numerical simulations, a risk analysis and a computer program to automate the prediction process.

Large-Scale Flume Test in Sand

Research Performed by:

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Project Completed:
12-31-06

What the Researchers Did

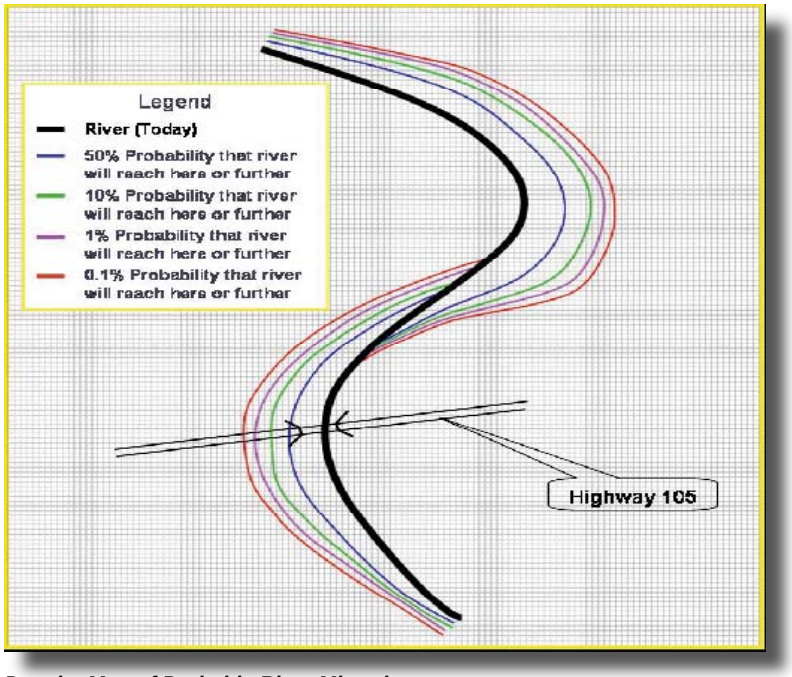
This project began with a comprehensive literature review. The research team then studied case histories including the Brazos River at SH 105, the Nueces River at US 90, the Trinity River at FM 787 and the Guadalupe River at US 59. These case histories helped to better understand the phenomenon and to better indicate factors influencing river migration.

A three-dimensional numerical simulation was used to depict the flow velocity field and the shear stress distributions within the curved channel. Very large-scale flume tests with two different soils (sand and clay) were conducted to represent the natural river processes.

To the researchers' knowledge, the flume tests conducted in this project are the largest in the world. A total of 18 cases in sand and 8 cases in clay tested different channel geometry and flow conditions. Erosion function apparatus (EFA) tests of the soils documented the critical velocity (v_c) and the critical shear stress (τ_c), under which the soil erosion was initiated by the flow. A risk analysis evaluated the possible locations of the river under the erratic nature of the process. A computer program was developed to integrate all components, automate the prediction process and facilitate its use.

What They Found

Prediction of river meandering migration is very complex. Simple procedures are quite inaccurate, and the time-step extrapolation method is unable to accommodate future changes in soil and flow conditions. The numerical simulation in this project indicated that the maximum velocity (v_{max}) and the maximum shear stress (τ_{max}) switch from one bank to the other in a curved bend. The flume tests and the case histories showed that there is a limit to the migration process and that there is a maximum migration distance (M_{max}).



Density Map of Probable River Migration

The most important parameters affecting M_{max} are the channel radius to width ratio (R/W), the bend angle (ϕ), flow Froude number (Fr) and soil properties of the channel bank. Migration in clay is much slower than in sand, and M_{max} is a function of the critical velocity or the critical shear stress of the soil. Considering the complexity of the phenomenon, it is best to present the results in the format of a risk map, which can be obtained through a Monte Carlo type of simulation automated by the computer program "MEANDER" developed as part of this project.

What This Means

Project 0-4378 produced a tool to predict the location of a river based on water, soil and geometry input. The soil is characterized by an erodibility curve (determined by EFA) subjected to a flow hydrograph over a given period of time. The hydrograph is typically obtained from a gaging station record – this record can be constrained with a 100-year or 500-year flow if necessary. Alternatively, multiple random hydrographs can be used to obtain the risk map of the river. The program MEANDER automates the process and accompanies the project report.

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